

CARIBOU RESEARCH AND MANAGEMENT
IN BRITISH COLUMBIA

Proceedings of a Workshop

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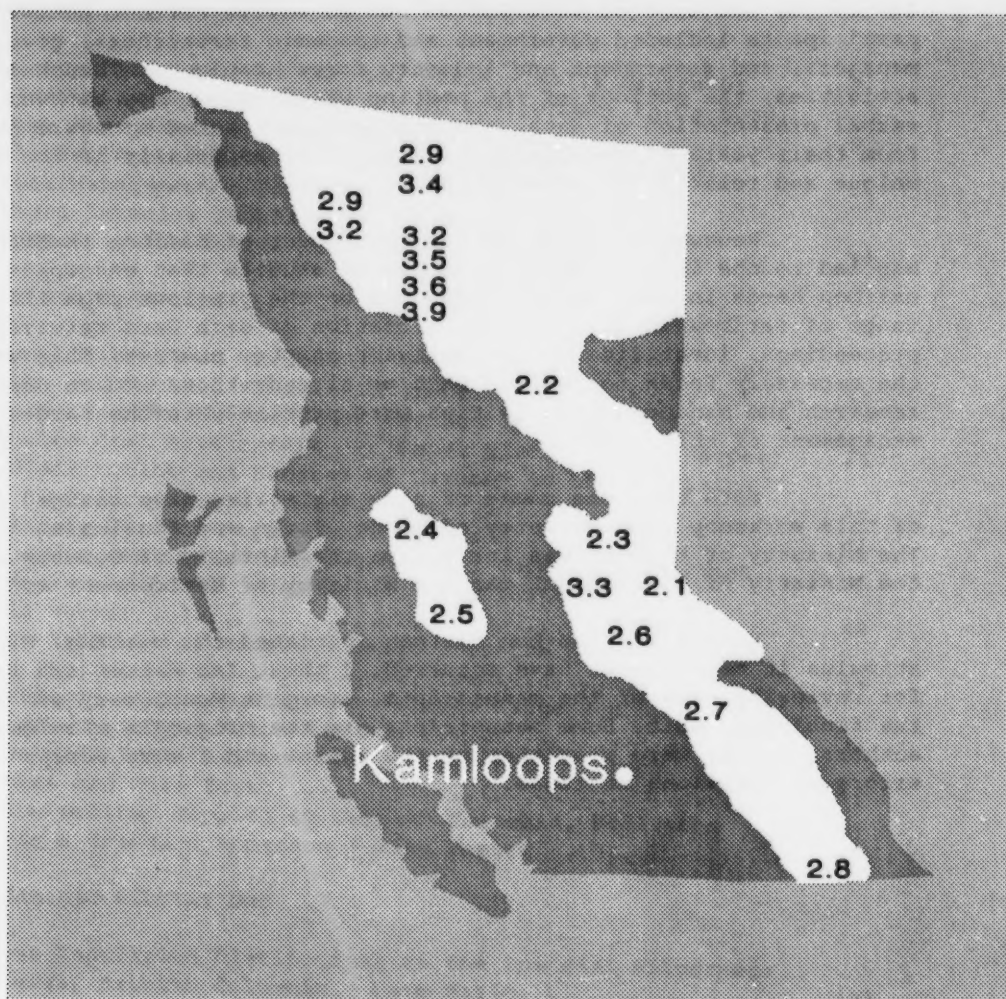
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The range of caribou (Rangifer tarandus caribou) in British Columbia and the location of herds mentioned by each chapter.

PREFACE

This eclectic group of caribou researchers and managers gathered to foster the exchange of information and to review current activities. The participants included government and academic researchers, government wildlife managers, and government and industry forest managers. Though reviewing activities, the outlook of the meeting was forward, not backward. Rather than a verbal presentation of data, the speakers were asked to share insights gleaned from their years of experience with caribou, especially if the insight was unique and relevant to other studies.

Renewed interest in the management of caribou in British Columbia has led to the initiation of a number of studies that encompass most of the caribou herds in the province. The map on the previous page illustrates the range of caribou in B. C. and the location of each herd referred to in these proceedings, identified by the relevant chapter numbers. This workshop provided the necessary focus to realize what we already know, and to direct subsequent research and management activities more precisely to the target of successful management of this species.

Note that the names of some ministries have changed since the date of this workshop. The Ministry of Lands, Parks and Housing no longer exists. The Ministry of Forests was for a time the Ministry of Forests and Lands and the Ministry of Environment was the Ministry of Environment and Parks.

Rick Ellis and Don Eastman initiated the meeting. Without their stimulus it might never have occurred. I thank Ian Hatter and Linda Stordeur for reviewing some of the manuscripts. Georgina Montgomery was invaluable with the final copy edit. Some manuscripts are the originals provided by the authors. Others were rewritten by the editor and I must accept blame for any errors or omissions in those.

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CHAPTER 1 INTRODUCTION

1.1 PROVINCIAL AND REGIONAL CARIBOU PLANS

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The provincial caribou plan (B.C. Minist. Envir. 1979) states the following objectives:

1. Increase the caribou population to at least 20,000 animals distributed on traditional ranges.
2. Provide an opportunity for people to view caribou in their natural habitat.
3. Provide 20,000 hunter days of recreation and an annual sustained hunter kill of about 1,000 animals.

The policy statement in the provincial plan states that: caribou will be managed as an integral part of wild ecosystems and as a game animal.

We will strive to maintain habitat necessary for the survival of caribou populations; some particularly accessible herds will be closed to hunting and managed primarily for observation.

To reach these objectives we would have to increase the caribou population from the present estimated population of 11,000 to 20,000; hunter days would have to be increased by 15,000 and the hunter take by 700. Such increases may not be possible or practical in view of a generally declining population in most southern areas of the province. Caribou are found in 9 of the 23 wildlife ecosystems in British Columbia.

A variety of management prescriptions have been undertaken in order to move us closer to meeting our provincial objectives.

In 1978 compulsory inspection was initiated for all caribou. The hunting of caribou was limited to the taking of only males and several units were closed to caribou hunting. Since 1978 the hunter take of caribou has remained stable at between 308 and 348. This compares with an estimated hunter kill of from 1450 to 1700 during the period from 1967 to 1973 a drop to one fifth the earlier kill. The total number of caribou licences sold has declined from 7748 in 1973 to 1410 in 1984, so we have a drop in caribou hunters that parallels the drop in caribou harvest or visa versa (Table 1).

Critical caribou habitat has been identified and in some cases we have had limited success in protecting these areas in cooperation with the Ministry of Forests. In 1981, the provincial forester announced that 10,000 hectares in the Kamloops TSA be designated as an environmental protection area to benefit caribou. We are continuing to try to have the Minister of Forests set aside critical old growth caribou range primarily for use by caribou or to follow a prescription that will minimize the effects of logging on Caribou. Because the Ministry of Forests and the Ministry of Environment could not agree on reservation of forest areas for caribou there have been at least two Ministries to resolve. Ray Addison will be telling you something about this and I am sure Ralph and others will also have some comments.

Table 1. Resident and non-resident caribou licence sales and harvest.

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
# of resident caribou licences sold	3016	2442	2400	1692	1563	1385	1556	1063	1081	1006
# of non-resident caribou licences sold	823	908	965	602	624	499	462	440	373	404
Total number sold	3839	3350	3365	2294	2187	1884	2018	1503	1454	1410
	<u>Either sex harvest</u>		<u>Bull only harvest</u>							
	<u>Hunter sample</u>		<u>Compulsory Inspection</u>							
Resident harvest	501	405	386	127	151	141	131	152	148	152
Non-resident harvest	454	442	427	206	197	200	185	178	160	184
Total number harvested	955	847	813	333	348	341	316	330	308	336
Resident success %	17	17	16	7	10	10	8	14	14	15
Non-resident success %	55	49	44	34	32	40	40	40	43	45
% of Caribou taken by non-residents	48	52	53	62	57	59	58	54	52	55

Recent work with radio collared caribou is providing valuable information on distribution and movement patterns necessary to manage caribou on a herd basis. This work I believe is the best hope we have to gain a better understanding of what we really need to know to determine what constitutes caribou habitat and what effects modifying that habitat by construction of access roads or the removal of old growth timber has on our caribou herds. I also believe that it is through monitoring radio marked animals that we will be able to improve our inventory information. Radio telemetry studies have been carried out in several locations in B.C. notably Spatsizi; northern Tweedsmuir; Southern Tweedsmuir; Quesnel Highlands; Revelstoke; Wells Gray. You will hear some details of this work from Dave Hatler, Tom Smith, Rick Marshall and Dale Seip.

Certain accessible populations are being managed primarily for observation and have been closed to hunting. Examples are the Southern Selkirk International herd; Wells Gray; Telkwa; Yellowhead.

Two recent transplants were made to try to reintroduce caribou into areas of their former range: McClinchy Creek and Sugar Lake. The animals equipped with radio collars at McClinchy returned to their original area but the animals in the Sugar Lake area are staying in the release area and have produced calves. Plans are in progress to transplant caribou from B.C. to their former range in northern Idaho.

Predator control in both the Horseranch area and in Tuchodi area appears to have had positive results in increasing caribou survival. John Elliott will be talking about this tomorrow.

In spite of our attempts to increase caribou populations, population estimates indicate a decline in most southern caribou populations since 1978 even though most of these populations have been closed to hunting. A notable exception to this pattern is the increase in population estimate for the caribou in the Itcha-Ilgachuz area where there has been a three fold increase in the population estimate under limited hunting. Tom Smith will be talking about this population this afternoon.

The problems that were identified in the 1979 plan are still with us, these include the following:

1. Logging is destroying some winter ranges.
2. Some herds have been reduced because of past overharvest or habitat destruction or both.
3. Inventory is incomplete. I have some tables (Table 2 and 3) which update those in Bergerud's report (Bergerud 1978) that provide summaries of our population estimates and percentage calves in the various herds. This information however is not too consistent. In most cases the population estimate is a minimum figure based on the total number of animals seen. In other situations; Spatsizi; Tweedsmuir; and Itcha-Ilgachuz, a correction has been made to expand the total seen to the total estimated population. Not all the calf counts were done during the same period so some counts represent July counts and others may represent February counts.
4. Predation may be limiting some populations.

Table 2. Caribou recruitment as indicated by the proportion (%) of caribou calves in major herds in 1977-1983.

Region and Herd	Percent Calves (Sample Size)						
	1977	1978	1979	1980	1981	1982	1983
REGION 5							
Ilgachuz Mtn.	16%(140)	36%(183)				26%(368)	25%(410)
Itcha Mtn.	16%(140)	30%(170)				27%(342)	23%(365)
Rainbow Mtn.	10%(41)	30%(37)					20%(150)
REGION 6							
Kawdy Plateau	5%(721)	22%(223)	20%(321)	17%(550)			
Level Mtn. (test area)	5%(630)	25%(286)	7%(473)	16%(311)			
Spatsizi - Caribou Mtn.	6%(410)	13%(526)		12%(623)	8%(457)	14%(459)	13%(1041)
Spatsizi - Tomias Mtn.	7%(1134)	13%(453)					
Tweedsmuir Circle	17%(30)	22%(77)				12%(169)	
REGION 7							
Axelgold - Sikanni	No count	8%(13)					
Cypress	None seen	33%(76)					
Horseranch (wolf control)	6%(237)	16%(268)	17%(274)	16%(311)			16%(209)
Lawyers Pass	12%(825)	10%(493)	6%(282)	16%(95)			
Liard Plateau	10%(93)	17%(119)					
Pink Mtn.	16%(146)	29%(211)					
Prophet R.	18%(44)	33%(219)					21%(179)
Tuchodi R.							21%(145)
Racing R.							

Table 3. Estimated minimum populations.

	YEAR							
	1977	1978	1979	1980	1981	1982	1983	1984
REGION 3	515							300
REGION 4	500							400
REGION 5								
Ilgachuz Mtn.	140	183				368		1300
Itcha Mtn.	140	170	509			342		75
Rainbow Mtn.	41	37						230
Quesnel Highlands								
REGION 6								
Kawdy Plateau	721	400	537	550				1100
Level Mtn. (test area)	630	305	472	311				450
Spatsizi - Caribou Mtn.	410	526	805	623	457		459	2000
Spatsizi - Tomias Mtn.	1134	453						500
Tweedsmuir Circle	30	77	23					75
Telkwa	40							100
Edziza	75	43	50					450
Rancheria	500		194					200
Swan	200	454	291					400
E. Atlin	250							100
W. Atlin	150							150
Pitman	250							—
Misc								

Table 3. Continued.

	YEAR							
	1977	1978	1979	1980	1981	1982	1983	1984
REGION 7								
Axelgold-Sikanni		13						
Cypress		76	131					
Horseshoe (wolf control)	237	263	274	311	329	337	250	210
Lawyers Pass	825	493	313	95				800*
Lizard Plateau	93	397	301					200
Pink Mtn.-Halfway R.	275	211	274					400
Prophet R.	75	219	115					200
Tuchodi-Kluschesi	350							350
Racing R.	60	13	67					150
Toad River	250	58	261					200
Rabbit-Gataga R.	200		40					300
Lay Range	100							100*
Ospika R.	100							100*
Dell Mt.	100							100*
Butler	50							50*
Germansen	100	8	15					100*
Yellowhead	200							500
N.E. Coal	300							300*
Graham R.	250							250*
PROVINCIAL TOTAL	9290							12,140

*estimates - no recent counts

5. New access roads are making many populations vulnerable to over hunting and poaching.
6. Some habitats that appear that they should support caribou are unoccupied.
7. Illegal harvest and highway or railroad kills may prevent some herds from recovering to former levels.
8. The importance of behaviour and herd structure is still imperfectly understood.

Various regions have had regional plans of one type or another for many years. Recently species statements have been prepared for caribou in each of the phase I regional wildlife plans. Most of these provide an update on caribou in the region but do not lay out options and strategies for management. In the Williams Lake prototype wildlife plan, two different management options are presented as well as management strategies and priorities. This allows for allocation of resources based on the plan.

Hatler and Stevenson have recommended that the caribou areas of the province be designated by priority for their importance in meeting provincial objectives.

Hopefully the information and exchange of ideas that is presented at this workshop will lead to an improvement in our management of caribou so that we can increase caribou numbers and distribution in our province for future

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1.2 PROVINCIAL APPROACH BY MINISTRY OF ENVIRONMENT TO CARIBOU HABITAT MANAGEMENT

Ralph W. Ritcey, Fish and Wildlife Branch, Ministry of Environment, 1259 Dalhousie Drive, Kamloops, B.C. V2C 5Z5.

This seemed like a good opportunity for me to find out if there really was a provincial approach to caribou habitat management in existence. If there was not, to point out the need for one and to suggest what it should be. Possibly the task of doing this would have been easier had I the benefit of two days of workshop proceedings to review but speaking without this information may lead to more discussion after I conclude.

It quickly became apparent to me that my suspicions were well founded. Namely, that although there are a number of vigorous regional habitat protection programs, there is no provincial approach. Further, in our present state of knowledge, management is synonymous with protection. This is as true in the parts of the province where caribou are largely dependent on arboreal lichens for winter survival as it is in the northerly and westerly ranges where terrestrial lichens are the sustaining winter forage.

Throughout the province the proliferation of access is seen as a major threat to caribou. There are active regional programs to restrict road construction, to put roads to bed after logging and restrictions on the use of off road vehicles to reduce the threats of harassment and illegal killing. However, there are no situations where access is being provided to allow people greater access to caribou either for viewing or for hunting.

Protection of the forage resource base on the other hand, is seen as a major issue in the range of caribou dependent on arboreal lichens for winter survival. Even here, the perception of urgency varies from region to region partly as a result of the general uncertainty concerning present population sizes and the immediate cause of recent increases or declines. The search for causes of historic and recent population declines (Bergerud 1974, 1978, Bergerud et al. 1984) and the concern over the precision of censuses (Stevenson and Hatler 1985) begs the larger question of population extinction through range loss. The shrinkage of occupied range in southern British Columbia has been estimated by Bergerud (1978) to be 9,000 square miles (23,310 km²) which he thought to be "not so extensive". However the remaining occupied range of the southern (arboreal lichen eating) caribou is only 29,000 square miles and still shrinking. Inventory flights over the last few years suggest that Raft Mountain south of Wells Gray Park can now be 'written off' as far as caribou range is concerned. Burns, logging, and snowmobiling have rendered this range unusable. There are many similar examples of abandonment of traditional range after removal of the mature forest.

The clear and undebatable fact is that three recent telemetry studies of arboreal lichen eating caribou that will be reported on here have revealed virtually no winter use of forests less than the present rotation age (100 years) of forest harvesting (Ted Antifeau in the North Thompson, Keith Simpson at Revelstoke and Dale Seip in the Quesnel Highlands). This situation has also been observed over many years in Wells Gray Park.

What of alternative cutting practices? Could selective logging be carried out with little harm to caribou but at the same time delivering the economic and silvicultural benefits of clearcutting? Two B.C. studies suggest not. Stevenson (1979) concluded that on her Selkirk study area, logging to a 51 cm. stump diameter would reduce available lichen to just over 1/4 of its original amount. Palmer (1982) found that the best tree type for lichen production on her sub-alpine study area in the North Thompson was a mid-canopy, mid-life, medium vigor, open growing Abies lasiocarpa, but stated that this tree type is not desirable from a silvicultural point of view.

Given that there is no evidence that within the range of arboreal lichen feeding caribou that timber harvesting (based on present rotation lengths and clearcutting) can take place without major long term damage to caribou habitat and given that the commercial value of these forests is high, (Tolnai 1979) what should be the provincial approach to protecting habitat? All regional efforts at habitat protection are in the final analysis merely stalling tactics, for in the end, all economic old growth timber will be harvested unless it is removed from the AAC. An action that must be taken in Victoria.

Clearly there must be joint action by Forest and Environment Ministries if effective and economical habitat protection is to be achieved. Firstly, the Ministry of Environment must extract from the Ministry of Forests a rather firm estimate of the maximum permitted reduction in annual allowable cut for caribou habitat protection in each Timber Supply Area. Without this information we cannot have an effective, long term plan for protecting caribou habitat. With this information, and using the planning framework provided by Stevenson and Hatler (1985), the best of several strategies can be chosen. The only safe option at present seems to be maximum protection (i.e. no logging, no access) of high quality habitat in core areas containing viable populations. On the periphery of the core, typical stalling tactics should be applied, selective logging, smaller ratios of cut to leave and employment of longer rotation lengths. Habitat for caribou far from the core periphery would be almost written off and logging could proceed with minimal guidelines for habitat protection.

I believe that there can be major benefits accorded to caribou from minor adjustments in the AAC. The 10,000 hectare reserve on the southern border of Wells Gray Park where no logging is permitted involved less than a 0.6% reduction in the AAC for the Kamloops Timber Supply Area. However all of the reduction would come from 2 P.S.Y.U.'s and mostly from the cutting area of one company.

Obviously, some reallocation of timber and shifting of cutting priorities from old growth at high elevations to maturing second growth at lower elevations may be necessary to assure continued operation of mills presently dependent on a wood supply from critical caribou habitat.

While the selection of core populations to be protected should be by Victoria in accordance with provincial priorities, the boundaries of reserve areas and the formula for applying the reduction of the AAC should be jointly worked out between the regional and district staffs of Ministries of Forests and Environment.

It would be understood, of course, that if future research should show that caribou of the interior wet belt do not need extensive stands of mature forests for survival, then the reserves could again be included in the AAC, provided that logging was carried out under prescription that would provide the necessary forage base.

What of the habitats of the northern and western caribou (comprising more than 90% of the province's population) where terrestrial lichens supply most of the winter forage? Undoubtedly these habitats are more resilient than those in the wet belt of the interior. Lichen stands may reach near maximum production as early as 70 years after disturbance by logging and fire and begin to decline in productivity sometime after 100 years. Therefore, the frequent disturbances by fire present in the northern part of the province are constantly producing new range. Here it should be possible in the near future to implement a habitat management plan that goes beyond mere protection. What is needed is a biophysical inventory and a detailed fire history for caribou range to work out a range renewal rotation for the major caribou ranges of the north. Again the basic initiative should be from Ministry of Environment to Ministry of Forests in Victoria with implementation resting in Regions and Districts of Environment and Forest Ministries.

To sum up then - in the range of the arboreal lichen feeding caribou we need to establish a system of habitat reserves based on provincial priorities. In the range of the terrestrial lichen feeding caribou we need an active habitat management scheme to ensure a productive forage base for caribou. Throughout the province the access problem is probably best handled regionally.

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1.3 PROVINCIAL APPROACH BY MINISTRY OF FORESTS TO CARIBOU HABITAT MANAGEMENT*

Ray B. Addison, Strategic Studies Branch, Ministry of Forests, 1450 Government Street, Victoria, B.C. V8W 3E7.

A provincial approach to caribou habitat management has not yet been developed by the Ministry of Forests. Some of the conflicts that have arisen over timber harvest in caribou habitat have been settled locally, at the regional or district level, but most issues that have become of provincial concern have been deferred. The Environment and Land Use Committee (ELUC) of Cabinet has not acted on the reports of the old growth task force. The problem analysis by Stevenson and Hatler is the first step toward understanding the relationships between caribou and their habitat, and will allow the consideration of a provincial policy.

* This summary was written by the editor from notes taken at the workshop. The editor accepts full responsibility for the content.

1.4 SOUTHERN INTERIOR INDUSTRY PERSPECTIVE ON CARIBOU MANAGEMENT

Bob Cavill, Interior Lumber Manufacturer's Association, Kelowna, B.C.

On behalf of the southern interior forest industry, its certainly a pleasure to speak to you today. The area in which we operate renders successful examples of caribou/timber management as well as some of the more difficult ones.

You know our forest companies resemble caribou herds in many respects. Think about our forest industry as a living, functioning entity. Consider for a moment that a forest company:

- 1) needs an area of forest, ... just like caribou.
- 2) needs continued sustenance - in sufficient quality and quantity - just like caribou.

In fact this forest industry community, its timber supply, mills, workers, and customers have, over time, carved a 'niche', if you will, every bit as essential as the caribou's. This 'community's' survival depends on the continued assurance of this niche.

Look at the 'complex' which has developed. The forest provides the timber, which the mills, in turn, digest. Forest products are created and passed on to customers. They, in turn, reimburse the producer for his efforts. This provision of monetary return is the nourishment required by the producer to maintain or improve equipment, reimburse workers, manage loans, pay stumpage and taxes of all sorts, and if, by chance, there's profit left, it's used to repay those who were prepared to take the risk in the first place the shareholders.

A portion of taxes goes to crop renewal and so this complex forest industry 'community' is sustained. Or is it?

No, a viable forest industrial community is regulated by a series of other factors including AAC's, tenure agreements, management and working plans, cutting permit applications, 5-year development plans and so on. These constraints contribute to the determination of our 'behaviour' and can profoundly affect our long term 'survival'.

Recently our forest industry 'beast', has experienced additional 'stresses', including U.S. attempts to reduce imports of Canadian lumber, difficult logging shows, mountain pine beetle, and spruce bark beetle outbreaks, wild fires, constantly changing government policies, proposals for forest land withdrawals, decadent timber, the need for new marketing opportunities, etc. However complicated the situation, the forest industry will continue to be a major factor in B.C. Of necessity, we will continue to adapt to new environs. There is no doubt:

We have a complex, sometimes fragile yet continually viable and ongoing forest industry 'community'. Timber will continue to be its lifeblood.

Just as you would wish every 'survival' advantage for the caribou, we want the best for our industry. We believe that both 'beasts' can survive despite the present 'competition' for forest land. 'People' must find positive solutions. Isn't it true that these two resources can compete and yet coexist?

So how are we going to maintain timber supplies for our mills as well as protect caribou populations? We all have a job to do.

Evidently there are some who continue to say "NO to LOGGING; CARIBOU ARE IN CRISES".

Others say "YES, to caribou and timber harvest - WORK IT OUT - PLAN - DO SOMETHING.

The vast majority of us in industry do not claim to be wildlife experts. But we are intimately involved because, for better or worse, we initiate activity in the forest. In fact, as a result of our activities, certain wildlife species benefit. We have demonstrated repeatedly that if timber harvest is conducted properly, deer, moose, birds and many other forms of wildlife can be accommodated. In many cases the positive relationship between timber harvest and certain forms of wildlife is relatively simple.

We all admit that solutions to the caribou - timber interaction are complicated - nevertheless this is the challenge and must not be taken lightly.

Can we transcend some of the "old barriers"? Are we able to avoid the tendency for the "easy out" where wildlife interests simply support moratoriums, park preserves, etc. and industrial interests simply argue the economic benefits of logging (ie. jobs, taxes, living standards, etc.) Can we get down to the business of:

"INTEGRATED PLANNING"

It's largely up to you as resource managers. "Planning" - hard, thoughtful deliberations, - communicating with the other side - finding solutions.

The stakes are too high to do otherwise and there are solid examples of integrated planning in B.C. Consider the Selkirk herd successes and more recently the positive initiatives demonstrated in the Cariboo region.

If we don't pool our resources and thoughts, what's the alternative? We force politicians into the arena. Politicians are generally pushed, pulled, advised, tugged and harassed by all points of view. Then they are expected to make a decision. This process will continue if both sides will it - but successful resolution of any complex land use issue through this process will be "hit or miss" at best. The worst part is that the public could be the big loser if politicians feel compelled to force out a decision on land use.

I suppose this is where I differ from some of the previous speakers. ILMA believes that solutions can be found through "negotiation" - all sides sitting down together to carve out a resolution.

Another point! Some very good examples of coordinated planning exist in B.C. But these don't get the headlines. Because if issues are resolved locally - it's not news; it's handled. Let's face it, the media is largely in the business of dealing with conflict rather than cooperation.

Contentious areas - newsy areas - are those areas where effective dialogue does not exist. Resource managers are talking to politicians, they're talking to the papers ... but they are not talking enough to each other. Unfortunately this can and does happen.

Resource managers, whether they be caribou or timber proponents, can assume four basic stances.

The first two stances we'll look at are what we call "Basic Disclaimer Positions". Such positions evolve from a desire by possibly misdirected, albeit 'well-meaning' resource managers to continue operating in a void without meaningful involvement in a specific planning process.

I. "NO LOGGING - CARIBOU ARE MOST IMPORTANT"

(To support this point of view, garnish with appropriate metaphors such as "we can't take any chances", "the problem is reaching crisis proportions").

II. "LOGGING IS CRUCIAL - OTHER USES ARE SUBSERVIENT"

(To support this point of view talk employment, taxes, the economy, etc. All valid points in context, if you're doing a cost-benefit analysis ... but what about our objective? To integrate the two resources.)

Where do we end up when such stances persist? Generally such impasses will go right back to the reluctant politician for a decision.

The next two stances are what we call "Basic Management Positions"

III. "INTEGRATE RESOURCES - BUT NOT ON EACH HECTARE"

(A more responsible approach advocated by many wildlife managers. Automatically questions then arise:

1. Can logging practices be appropriately altered?
2. How many animals are we managing for? What are their specific needs?
3. Where are the 'acres' where we generally agree?)

IV. "INTEGRATE RESOURCES ON EVERY HECTARE - IF POSSIBLE"

(Another responsible approach many times accepted by responsible industry managers - same types of questions can be asked.)

We now have some common ground.

In fact, numbers III and IV form the basis for responsible negotiation.

Just as an example, I have been told by some of you, that timber harvest perse' historically has not been a major factor in reducing herds - rather it's the developments which tend to follow harvest (ie. increased access, illegal kills).

We believe that we can help you there; you have a strong ally in access control if it's warranted.

Policing of illegal kills - same thing.

So we're not asking you to roll over and play dead - no doubt the struggle for your resource will continue, as this is your responsibility. But let's move the forum to local planning by resource managers.

To finalize let me pose a couple of questions to you as professional resource managers.

- 1) Can we be positive? Can we get away from the subjective criticisms about timber harvest? "Logging mess", "unsightly" and "damaging" are merely subjective descriptions and lack that professional, scientific punch. Let's get specific.

and then

- 2) Can we avoid entrenching early, cutting off potential positive resolution? Instead can we agree on principles and objectives; meet, discuss and propose

A great many of you have already adopted this more laudible approach.

The fact that industry has been invited to attend this workshop bodes well for those wildlife managers who see the value in a cross-section of opinion and views. Hopefully we'll all benefit in the exchange of ideas and the relating of experiences which will take place over the next couple of days.

On the question of caribou research, let me just say that I am gratified by the fact that many of the latest findings appear to confirm a growing case for the potential of integrated management.

As I look around I see that there are other people from industry attending. Our primary purpose here is to look for opportunities to apply caribou findings and research to practical situations.

Thank you again for this opportunity.

CHAPTER 2 CARIBOU HABITAT

2.1 A STUDY OF WOODLAND CARIBOU IN WEST CENTRAL ALBERTA*

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A study of woodland caribou (Rangifer tarandus caribou) in the mountains and foothills of west central Alberta began in 1979 in response to declining numbers of caribou and increasing human activity. Of particular concern was the initiation of large scale timber harvest on the remaining foothills winter range of mountain caribou (a migratory variety of the woodland subspecies). Several decades of coal exploration, road and railroad construction and timber harvest already had greatly reduced the size of the winter ranges and possibly disrupted movements between seasonal ranges.

A review of Government of Alberta publications and interviews with people familiar with caribou in west central Alberta suggested that the mountain caribou population in the Grande Cache area had gone through two declines since the 1940's. The first decline in the late 1940's occurred after two severe winters and several years of high wolf numbers and intensive, small scale logging on the winter range. That decline was from an estimated 2000+ caribou in the 1930's to less than 300 by 1950. During the late 1950's and early 1960's, mountain caribou increased in numbers again, probably in response to a low level of hunting and a predator control program. However, by the mid 1960's, industrial development was expanding rapidly on the winter range and wolf numbers and hunting pressure were increasing. Through the 1970's, the caribou population declined from an estimated high of 1200-1800 in 1968 to a present low of less than 300. Currently, habitat loss and disruption, illegal hunting and predation continue to threaten the caribou populations of west central Alberta.

A capture program to radio collar caribou was required to obtain information on seasonal movements, location and extent of important use areas (winter range, calving and rutting areas) and population size, composition and distribution. Twenty-nine caribou were captured. Radio telemetry data showed that 2 populations of woodland caribou resided in the foothills winter range around Grande Cache; a migratory mountain/woodland variety that moved west to the mountainous regions in spring and returned in fall and a more sedentary woodland variety that remained year round in the forested foothills.

The mean distance between seasonal ranges for mountain caribou was 84 km. Mountain caribou calved, summered and bred in the alpine regions of north Jasper National Park, Willmore Wilderness Park and adjacent portions of British Columbia. They dispersed in small groups throughout the summer range. The summer range size of individual bulls was larger (mean = 95 km²) than the summer range of cows (mean = 24 km²). The spring move from the winter range

* Summary extracted by the editor from Edmonds, E.J. and M. Bloomfield. 1984. A study of Woodland Caribou (Rangifer tarandus caribou) in west central Alberta, 1979 to 1983. Alberta Department of Energy and Natural Resources, Edmonton, Alberta.

was abrupt and of short duration with cows moving before bulls, while the fall move tended to be more prolonged and sporadic with no difference in timing between the sexes. Snow conditions appeared to be the primary factor affecting timing of the spring and fall moves.

On the winter range individual mountain caribou used a large area in any one winter with a mean total winter range size of 415 km^2 . Movement ($>15 \text{ km}$) within the winter range was common but most mountain caribou localized their activity at some time during a winter. Areas of localized activity could vary in location between winters. Snow conditions, predator activity and location of suitable forage were the main factors affecting the frequency and distance of moves within the winter range. Some mountain caribou did not migrate to the foothills region in winter. That small number of caribou made seasonal movements on an east-west basis but remained within mountainous terrain throughout the year. The total area used by the mountain population was $14,200 \text{ km}^2$. The total summer range was 4345 km^2 and total winter range was 4363 km^2 .

Mountain caribou calved in the first 2 weeks of June in open alpine or adjacent subalpine forest. Mean elevation was 1844 m (6050 ft). Rutting activity appeared to peak around mid October and was concentrated in traditional areas along the Continental Divide and the Jasper National Park/Willmore Wilderness Park boundaries. Both cows and bulls moved to those areas. Rutting activity primarily occurred in the alpine or at the treeline and the mean elevation was 1900 m (6230 ft).

The mean distance between seasonal ranges of the more sedentary woodland caribou was 31 km . Woodland caribou remained year round within the forested foothills to the east of Grande Cache. There was some overlap between seasonal ranges for 5 of the 6 radio collared woodland caribou. The spring move to the summer range was earlier for woodland caribou than for mountain caribou and again females moved before males. Woodland caribou dispersed over a large summer range but individual male and female caribou had a small summer range size (mean of 22 km^2).

The return to the winter range was indirect and prolonged and an individual woodland caribou's total winter range size was large; mean for males and females was 320 km^2 . Again, like mountain caribou, woodland caribou concentrated their activity during part of the winter. Snow conditions and predator activity appeared to be the main factors affecting frequency and size of moves by caribou while on the winter range. The total area used by radio collared woodland caribou during this study was 4590 km^2 (1170 mi^2). None of the radio collared woodland caribou moved to the mountains at any time during the study and no radio collared mountain caribou remained in the foothills region during the summer months.

Woodland caribou calved during the last week of May and first week of June. Calving habitat primarily was closed forest, usually in close proximity to open muskeg. Mean elevation was 1160 m (3866 ft). Rutting areas were

traditional and both cows and bulls moved to those areas. Rutting activity was seen as early as mid September but appeared to peak in the first 2 weeks in October. Most caribou were located in closed forest during the rut and the mean elevation was 1230 m (4105 ft).

The population size of mountain and woodland caribou was estimated to be 275 and 55, respectively. In both populations group size varied on a seasonal basis with the largest groups occurring in fall (during the rut) and winter. Group size was smallest in the spring (May-June). Sex ratios were the same for both mountain and woodland populations; 35% bulls and 65% cows. The mountain caribou population had relatively few mature adult bulls. The percentages of calves in the fall were 15% and 19% for the mountain and woodland populations, respectively. Adult mortality rates were calculated using mortality of radio collared caribou. The mountain caribou population had an annual adult mortality rate of 21%. Most mortality occurred in the alpine summer range with wolves and bears implicated in the deaths. Legal and illegal hunting in British Columbia and poaching in Alberta also were important factors affecting mortality rates of the mountain caribou. The annual adult mortality rate of the woodland population was 22% with wolf predation being the most likely cause. However, illegal hunting also was a factor. Disease and parasites were not of significant concern however, the muscle worm of mule deer (Parelaphostrongylus odocoilei) was found at low levels.

Densities of mountain and woodland caribou on their winter range were 1 caribou/16 km² and 1/40 km², respectively and densities over their total ranges were 1 caribou/52 km² and 1 caribou/87 km², respectively. The decline of the caribou populations in west central Alberta since the mid 1960's appeared to be the cumulative effect of predation, hunting and disturbance on the winter range.

Habitat use by mountain and woodland caribou varied most markedly during spring, summer and fall. At this time mountain caribou were found at higher elevations (primarily >1800 m), using a variety of alpine and treeline habitats. Woodland caribou in spring and summer, were found mainly around 1200-m elevation in forest and open muskeg habitats. In winter, the habitat used by mountain and woodland caribou was similar. However, mountain caribou primarily occurred at elevations between 1350 and 1800 m, while woodland caribou primarily were found at 1000 to 1350 m elevations. Woodland caribou used treed muskeg habitat to a greater extent than mountain caribou. The most commonly used habitat in winter for all caribou activity was pine and pine/spruce forests on flat terrain or on gentle to moderate slopes having a southeast, south, southwest or west exposure. Most feeding activity occurred in that habitat but meadows and treed muskegs also were important. Other than in very deep snow winters, open meadow habitat was selected for bedding. A paved highway crossed a portion of the winter range and we observed an increased familiarity with this road as the study progressed. The road allowance was used for feeding and the pavement as a source of salt. Use of winter habitat varied between years, with snow conditions being the main

factor affecting this variation; for example, in winters of deep snow (>80 cm) meadows were not used for feeding, bedding or travelling.

The pine and pine/spruce forests and dry meadows primarily used by caribou for feeding had good quantities of terrestrial lichens (mean biomass = 1350 kg/ha). Feeding habitat that was low in terrestrial lichen cover had substantial quantities of sedges or grasses, shrubs and forbs. Caribou cratering (feeding) sites were localized areas of high terrestrial lichen cover within a broad habitat of lower overall lichen cover. Forested habitat providing good terrestrial lichen cover was greater than 75 years in age, while forest habitat with the highest arboreal lichen production was greater than 130 years in age.

Caribou preferred to crater for terrestrial lichens than to forage on arboreal lichens. We found no limiting snow depths for cratering as long as the snow hardness values remained below 1200 gm/cm². In the winter of 1981/82, caribou were cratering through greater than 100 cm of snow and although arboreal feeding was more common that winter, it was rarely the exclusive feeding activity at a feeding site.

Caribou food habits were determined by plant fragment analysis of faecal material. In winter, terrestrial lichens averaged 66% of the diet with conifers, shrubs and graminoids comprising 28% of the remainder. In all winters, arboreal lichens accounted for less than 2% of the diet. The high amount of pine in the diet was most likely due to incidental ingestion as pine needles formed a uniform carpet through much of caribou feeding habitat. Caribou used mineral springs during 3 of the 4 winters of this study and analysis showed that sodium was the element most consistently present in high amounts. The summer and fall diet of mountain caribou had a high amount of shrub (primarily willow) but terrestrial lichens were still abundant, particularly in the fall.

During the 4 winters of ground tracking, 2 winters had relatively deep snow. However, the 1981/82 winter had well above average snowfall and the spring was late. In that year, daytime temperatures were low throughout the winter so the snow remained soft until early April. Caribou avoided open habitat for feeding, bedding and travelling. Arboreal feeding was common but cratering for terrestrial lichens was the primary feeding activity, even into April. In those deep snow conditions, caribou used cratering sites more than once and old trails were used repeatedly. Cratering was not a random process and the caribou were able to locate (smell) lichens through >79 cm of snow. In west central Alberta, caribou may rely most on arboreal lichen feeding for a time period in late winter/early spring when thawing/freezing conditions make cratering prohibitive, and the length of this period would vary from year to year. Mountain caribou wintering along the front range of the Rocky Mountains, also had the option of moving to the windswept alpine ridges on the western edge of their winter range when snow crusting was extreme.

Currently, quality and quantity of habitat for caribou on the study area is not limiting; however, the populations are still declining or at best maintaining a no growth status. Predation and to a lesser extent poaching are the main limiting factors. Mortality due to vehicles on Highway 40 also is an increasing problem. Despite careful planning of timber harvest on caribou range to maintain useable, preferred habitat, caribou in west central Alberta will continue to decline. As a mosaic of younger age forest develops (post-logging), moose, deer and elk will increase and invade areas that were previously caribou range. With an increased prey base, wolves also will increase and as has occurred elsewhere in North America, caribou will decline. In addition, greater access through logging roads will increase the number of caribou/human encounters and aggravate the current levels of man caused mortality.

Caribou have been described as an indicator species for wilderness degradation. Once the environment they live in has been altered, the resulting changes can be complex. If caribou are to remain as part of the wildlife component of west central Alberta, then systems other than habitat will need to be managed. Human activity and predator levels will remain as persistent problems but will also be the most difficult to solve.

2.2 DISTRIBUTION AND MOVEMENTS OF CARIBOU IN RELATION TO THE QUINTETTE COAL DEVELOPMENT*

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The distribution and abundance of caribou in the Quintette lease area of northeastern B. C. was monitored from September 1982 to January 1985. The population is estimated at 50 caribou with an average sex ratio of 59 males:100 females. Productivity in the fall was estimated at 20% in 1982, 11% in 1983 and 17% in 1984. Herd size has remained stable over the study period. Annual home range sizes of individual caribou which encompassed all seasonal ranges and travel corridors averaged 357 km² with a maximum mean travel distance of 36 km. From 40% to 50% of the herd moved to winter ranges in lowland boreal forest in the fall and returned to alpine and subalpine areas in spring. The remainder of the herd used alpine and subalpine areas throughout the year. Movements between summer and winter ranges took place within a 2 week period. Mean size of seasonal home ranges varied from a low of 14 km² in summer to maximum of 121 km² in spring. Caribou interaction with coal development activities and infrastructure is minimal. A portion of the herd may encounter the development site during seasonal movements and while on winter range. High predation rates, increased hunting pressure and disturbance resulting from improved access to caribou range are the greatest threats to the population. The overall impact of the existing mine development on the Quintette herd has been negligible to date.

* Abstract extracted by the editor from Sopuck, L.G. 1985. Movements and distribution of caribou in relation to the Quintette coal development. Renewable Resources Consulting Services Report. 56 p.

2.3 THE DISTRIBUTION AND HABITAT OF CARIBOU IN THE MOUNTAINS EAST OF PRINCE GEORGE

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INTRODUCTION

Since coming to Prince George in 1973 I have been observing and following the caribou in the Cariboo and Rocky Mountains to the east of Prince George. In the past five years I have made greater efforts to learn all I could about numbers, distribution, habits and habitat of these animals. It was not until 1983 and 1984 that a concerted effort was made to inventory populations. However, in the paper that follows much of the information presented was not gathered through any study under the auspices of the Wildlife Branch, but during the course of weekend recreational activities like hiking and skiing.

The need for indepth study of the caribou in the area east of Prince George has been building for several years. Caribou hunting was stopped in 1978 as the population was thought to be low and declining. The decline, which had been going on for many years, was thought to be the result of a combination of hunting pressure, poaching, road and rail kills, predation, habitat loss, disease and perhaps weather. Of particular concern was forest harvesting as logging was removing large acreages of old growth forest; the same forest habitat on which the caribou were thought to depend for food and shelter. With the logging access was also improving rapidly and, as a result, the mountains were getting increased use by recreationists. Since 1978 we believe the overall population has been holding its own, however, losses appear to be continuing in a few locations with increases in others.

Michael Bloomfield carried out a study during 1976 and 1977 (Bloomfield 1979), however, the emphasis of his work was the vegetative complex of the subalpine forest. He saw very few caribou. He did attempt to estimate populations but this was based on a review of historical records and interviews of guides and trappers. Stevenson and Hatler (1985) in their review of caribou management and research used Bloomfield's thesis in conjunction with additional sightings collected up to 1983.

The major stimulus in recent years for improved information on caribou numbers, distribution and habitats was a dramatic increase in timber harvesting as a result of blowdown and spruce bark

beetle outbreaks. But better information was also needed as the Prince George Timber Supply Area (TSA) plan was in preparation and most old growth forest was committed to the annual allowable cut (AAC). If we were to have meaningful input to the TSA plan we had to have much better information on caribou. Finally, we needed better data for management purposes.

STUDY AREA

The study area is shown on Figure 1. It includes the northerly part of the Cariboo Mountains, the mountains on the easterly edge of the Fraser Plateau, the McGregor Mountains and the Rocky Mountains west of the continental divide between Robson Provincial Park and the Pine Pass. The study area is split by the Rocky Mountain Trench which contains the Fraser River, the Canadian National Railway and Highway 16. Most effort was spent in the McGregor Mountains and the portion of the Cariboo Mountains north of Bowron Lakes Park.

The McGregor Mountains, the mountains on the Fraser Plateau and the portion of the Cariboo Mountains north of Bowron Lakes and Dome Creek are generally under 2000 m elevation and have been rounded off by continental glaciers. Slopes are generally under 30% with slopes over 50% relatively rare. From Dome Creek southeast to Valemount the Cariboo Mountains increase in height with extensive areas above 2000 m. Land over 2300 m was not over run by continental glaciers and is now dominated by jagged peaks. The valleys are U- or V-shaped and slopes are generally very steep with extensive areas over 50% gradient. There are scattered goat populations. The south and westerly side of the Rocky Mountains to about 2300 m was also glaciated and rounded off but these slopes tend to be steeper than those in the McGregor or north Cariboo Mountains. Here, too, there are scattered goat populations.

The treeline is about 1800 m in the northern part of the study area but increases to about 1950 m in the Valemount area. Forest dominated by alpine fir (Abies lasiocarpa) generally begins between 1300 m and 1500 m above sea level. Throughout the study area the upper 300 m of this forest is largely open parkland or Krumholz-type although this is influenced by exposure, soils and slope steepness. Below the subalpine forest there is almost always a belt of forest dominated by Engelmann spruce (Picea engelmannii). This belt is variable in altitudinal width and may extend down to the valley floor. Below the spruce belt the forests become much more variable in composition. Cedar (Thuja plicata) mixed with hemlock (Tsuga heterophylla) is common between 550 and 1100 m near the Fraser River and in the McGregor



Mountains. Extensive areas of lodgepole pine (Pinus contorta) occur from the valley floor up to about 1100 m (higher along the Rocky Mountain Trench south of McBride) on drier sites. White spruce (P. glauca), balsam, black spruce (P. mariana) and even Douglas fir (Pseudotsuga menziesii) also occur at lower elevations. Deciduous tree species generally form an inconspicuous element of the forests in the study area except, again, south of McBride.

Logging is widespread and, aside from the Morkill, Goat and Raush Rivers, all parts of the Study Area are accessible by roads. Except in the Cariboo Mountains southeast of Dome Creek, logging has been concentrated in the spruce, spruce-balsam and pine stands of lower and middle elevations. Southeast of Dome Creek along the Trench there has also been extensive cutting of the upper elevation spruce types in recent years. A small amount of cedar is being cut primarily along Highway 16. For the past five years logging has been largely concentrated in areas infested with spruce bark beetle. The two areas hardest hit by the beetles have been the upper McGregor River and the upper Bowron River. Approximately 30,000 hectares of spruce forest has been removed in the upper Bowron in an attempt to control the beetles and to salvage killed trees. Initially the Forest Service attempted to remove just areas under attack and areas with the worst kill but the beetle populations exploded resulting in 80 % or more of the mature spruce over tremendous areas being attacked and killed. One must see the clearcuts to really appreciate their size and extent. Almost nothing remains below 1250 m in several valleys resulting in forested ridge and mountain tops being completely isolated from each other. There is about one more winter and summer of extensive beetle salvage logging. If there are no further outbreaks the Forest Service assures us logging in the general area will be restricted for many years.

METHODS

The population and distribution information is derived from helicopter surveys supplemented by observations from my own field work or collected from a variety of other sources including motorists, loggers, fellow hikers and skiers, and other pilots. Some reference was made to the observations listed by Bloomfield (1979) and Stevenson and Hatler (1985) where current information was poor or lacking. To analyze the data I subdivided the study area into homogeneous subunits based on geographical features, management unit boundaries, and/or data reliability.

Through the process of trial and error we have found the only time of the year during which it is possible to conduct inventory surveys of caribou in the mountains is in late winter. We have found only minor use of alpine habitats or of snow patches in the summer months. Even in some winters it is not possible to carry out surveys as snow conditions keep the caribou in heavier timber at lower elevations where they are very difficult to locate. I carried out intensive surveys of the Cariboo Mountains and Fraser Plateau mountains February 21, 23, and 29 and March 6, 1984, and of the McGregor Mountains and adjacent parts of the Rocky Mountains March 27, 1985. In both years helicopter surveys of smaller pieces of the study area were made incidental to other game surveys and also by Northwood Pulp and Timber staff. The conditions for helicopter surveys were ideal. Each day the weather was sunny with excellent visibility and light winds. No new snow had fallen for 1-3 days and tracks to at least 10 days of age were visible. In both years there was average amounts of snow but frequent warm spells had settled and solidified it making it relatively easy for the caribou to move about. Most caribou were in the upper subalpine and parkland forest types. Regardless of snow conditions, however, some caribou remained at lower elevations as was attested by coincidental observations along Highway 16 and elsewhere and our inability to sight caribou in a few areas where other information indicated they should be present.

When tracks or animals were located the first priority was to get a total count and the number of juveniles. Where possible the number of adults with and without antlers and the number of males and females was determined, however, this information was often overlooked in order to minimize harassment. When the caribou were not located, then the number present was estimated from tracks. We made notes on elevation, exposure and habitat within which animals or tracks were found. These notes were generalized as some groups had utilized areas greater than two square kilometers over as much as 500 m of elevation.

Information and comments on seasonal habitat use, calving, and rutting are derived not only from these sources but also from extensive observations I have made over the past 10 years while hiking and skiing in the mountains within the study area. I spend most weekends in the mountains 12 months of the year.

RESULTS AND OBSERVATIONS

Distribution and Abundance

Table 1 summarizes the population estimates by subunit and for the entire study area. My minimum winter population estimate for the Fraser Plateau and Cariboo Mountains is 232 to 263 and for the McGregor Mountains it is 150 to 158. My minimum winter estimate for the Rockies southeast from the McGregor River to Robson Park is 30, for the Herrick Creek area it is 30, and for the Parsnip River area it is 50. This gives a total minimum estimate for the study area of 492 to 531. Because of repeated observations over several years I have considerable confidence in the population estimates for the Fraser Plateau mountains, the McGregor Mountains and the portion of the Cariboo Mountains northwest from Dome Creek. Even so, the estimates are likely low as the portion of the population that resides at lower elevation in the different subunits is unknown. Lowland groups I knew about were included. I have confidence only in the minimum estimate for the remainder of the Cariboo Mountains but the estimated populations for the Rocky Mountains is only a best guess based on my own scattered observations and observations listed by Stevenson and Hatler (1985). Based on our experience in the McGregor and Cariboo Mountains I suspect actual numbers of caribou in the Parsnip and Herrick areas to be much higher than indicated. My population estimates for the Fraser Plateau, McGregor and Cariboo Mountains are much higher than those given by Bloomfield (1979) and by Stevenson and Hatler (1985) but I believe they reflect improved data and not any substantial increase in numbers.

The populations on George Mountain and in the Narrow Lake area appear to be isolated from each other and from those in the Cariboo Mountains. Because of logging of lowland forests the caribou in the Raven Lake area appear to be largely isolated from those in the remainder of the Cariboo Mountains. While we have observations to indicate some movement of animals between the Cariboo Mountains and the Rockies, this does not appear to be extensive and is likely decreasing as the Fraser River bottomlands are logged and developed for agricultural purposes. Most caribou in the McGregor and northerly Cariboo Mountains appear to occupy relatively small areas and simply move up and down the mountains with the seasons. There may be movement of animals to the McGregor Mountains from the north (Parsonip) and east (Herrick and Holycross) in winter but this has not been confirmed. The Alberta studies have clearly shown a portion of their caribou cross the continental divide to spend the summer north of McBride. It is probable that similar movement is occurring between the Herrick and Parsnip subunit populations and the Kakwa - Monkman areas as well. However, as there is no information on the degree of mixing and interchange, I have not attempted to estimate summer populations in these areas.

Unit and subunits	Management Unit	Minimum Estimate
Fraser Plateau		
-George Mtn.	7-09	11-15
-Narrow L.	7-07	<u>32-33</u>
		43-48
Cariboo Mountains		
-Haggen Cr.	7-06	50-55
-Raven L.	7-05	50-55
-Slim Cr.	7-05	28
-Dome Cr.	7-05	15-17
-Goat R.	7-05	0
-West Twin Cr.	7-05	26-35
-Raush R.	7-04	20-25
-Park	7-04	<u>0?</u>
		189-215
McGregor Plateau		
-Bearpaw Ridge	7-17	81-87
-Pyramid Mtn.	7-17	49-51
-Torpy R.	7-17	<u>20</u>
		150-158
Rocky Mountains		
-Holmes R.	7-03	30?
-Holycross Mtn.	7-17	0
-Herrick Cr	7-18	30?
-Parsnip R.	7-16 &	<u>50?</u>
	7-23	110?
Grand Total		<u>492-531</u>

Table 1. Caribou population estimates for study area. (?) = data is unreliable, see text.

Seasonal Movements and Habitat

The caribou in the study area are basically a forest animal. The prime movement is up and down the mountains and this appears to be dictated largely by snow cover and snow condition. During the summer months of July through September virtually the entire population appears to use the sub-alpine forest above 1400 m. There are few observations of animals or of sign below 1400 m. There is some use of alpine meadows but very little use of bare alpine ridges. On only two occasions in the past 12 years have I seen animals using snow patches and both times it was around August 1. I have seen very little other evidence to suggest snow patches are being sought out. In any case, in most years snow patches on the McGregor Plateau, Fraser Plateau and north Cariboo Mountains are absent or scarce by the first of August.

The caribou leave the alpine as vegetation becomes covered by snow. Significant amounts of snow usually fall in the alpine and the subalpine parkland by mid September, however, the snow generally does not remain until the second or third week of October. It is not until there is more than 50 cm of soft snow that most caribou seem to move to mature balsam or spruce-balsam forest at lower elevations. By late October, a portion of the population is down to 1200 m. By the second or third week of November, occasional animals including both females with calves and adult bulls are seen along Highway 16 at 700-800 m. There are three locations between the Bowron River and McBride where there are frequent sightings in association with old growth cedar-hemlock forest. For the past seven years another band has frequented a predominantly pine stand near Small River south of McBride. In much of the study area, however, caribou that descend to lower elevations use spruce-balsam types as nothing else exists. They also traverse logged areas but it is unknown what use they make of them. Not all caribou move down in response to increasing amounts of snow.

Perhaps half of the population remains in the subalpine forest near the parkland belt and contends with the increasing amounts of snow. Occasionally snow is chest deep and the caribou plough troughs as they move about to feed. However, such conditions usually do not last more than a few days. Wind is frequent and often strong and it settles the snow making it relatively easy for the caribou to move. Inversions may also occur with above freezing temperatures at subalpine elevations even though it may be very cold in the adjacent valleys.

From the end of December onwards, there is considerable variation between years in the elevation where caribou concentrate. Most winters the snow builds up through December at all elevations and by January most caribou that had moved to low elevations in early winter have ascended the slopes to 1100 m or higher. If the snow compacts from warm temperatures, the caribou are concentrated in the upper parts of the subalpine forest by late February. However, in two winters in the past 12 years (1982-83 and 1976-77) the snow pack did not build up and there was little snow below 1250 m. Further, the snow never consolidated in the subalpine forest and made travel very difficult throughout the winter. In those two winters, the caribou that stayed high in early winter eventually descended into dense forest below 1300 m and stayed at the lower elevations until snow melt.

The caribou located during helicopter surveys in February and March were not randomly distributed. Fifty six percent of the groups were on slopes with a northern exposure with only 13 % on southern exposures. Random observations over several years suggests there is some preference for northern exposures through the entire winter. This selection, however, could be related to forest type, food supply or other factors. About 70 % of the groups were on slopes with 0 - 15 % gradient and only 10 % were on slopes over 30 % gradient. While we found no groups on terrain with an average gradient over 50 %, there was occasional use of such habitat. Throughout the winter, even when the snow is soft and travel is difficult, there is some use of steep slopes. We never saw tracks or caribou in younger types of immature forest although we did find some use of older immature forest. At least 80 % of all sign was in mature or over-mature balsam forest types. This observed use of mature balsam is likely biased as animals and sign are difficult to find in lower elevation forest. A few groups made use of open springs and tracks of three or four groups suggested the springs had been the focal point of activities for a week or more.

Anywhere from late March through April, most of the caribou descend to elevations below the receding snow line likely in search of new growth. It could also be in response to predators. When a group decides to go down, they descend very quickly. At snow line in early spring there is usually a 200 to 300 m belt of very rotten snow which the animals probably like to avoid so cross quickly. From late April through May, we again get numerous sightings from low elevations. Most observations of animals are in association with mature coniferous cover but logged areas are not entirely avoided. The caribou thereafter tend to follow the receding snow line upslope through May, June

and early July. However, as in early winter, a portion of the population does not descend to lower elevations but seems to wait for the snow line to come to them. Nonetheless, a few remain at low elevations either throughout the summer or they use the low elevations regularly.

Foods

Through the winter months, arboreal lichens form the main part of the diet of those caribou that remain in the subalpine forest. In tracking caribou, I have found selection for balsam and alder but their use is incidental and minor. In early winter arboreal lichens may be in short supply because snow has destroyed them on branches below the maximum snow pack depth of previous winters. Those higher on the trees are largely out of reach until the snow pack builds up. This may be one reason some caribou descend to lower elevations in early winter. Caribou will browse on huckleberry (Vaccinium sp.) but in the subalpine forest this shrub and all other terrestrial plants are soon buried in snow. Shrubs remain accessible longer at lower elevations but I believe arboreal lichens knocked to the ground by wind or snow is their main food.

The band of caribou which descends to the vicinity of Highway 16 south of McBride is somewhat unusual for this area in that it craters extensively. The area is dominated by lodgepole pine forest with relatively little snow. This forest type is relatively scarce and restricted to lower slopes along the Rocky Mountain Trench south of McBride. In addition to lichens, this band also uses shrubs especially Vaccinium. In 10 years, I have seen cratering only two or three times elsewhere and then only on alpine ridges.

We have no specific information on caribou feeding habits through the summer months.

Rutting and Calving

In October, most caribou are in the subalpine forest above 1250 m and it is here where the rut appears to be occurring. I have not found sign of rutting activities below 1250 m but that does not mean it does not occur. Neither have I found aggregations of caribou or sign in subalpine meadows or in the alpine. Tracks indicate some use of parkland habitat during the time of the rut but this use is likely influenced by the amount of snow.

As far as I can determine, most calving, like the rut, is also taking place in the forest. In 10 years, I have not found evidence of calving in the alpine or open parkland habitats although K. Child did on June 15, 1977. Most years the subalpine and alpine (except for windswept ridges) is still 100 % covered in snow in early June even on south exposures. Most years both animals and sign are scarce above 1600 m. In early June, tracks indicate the caribou are scattered from well below snow line up to about 1600 m. In June there is usually a belt of 200 to 500 m elevation with patchy snow and it is within this zone I believe most calving is occurring. Occasionally, the snow does disappear early and the parkland and subalpine is partially free of snow by the first of June. It is probable calving takes place at higher elevations in such years. It was such a year that Child found the evidence of calving in the subalpine at 1570 m.

Mortality

We have very little information on either causes of mortality or the degree of such losses. The hunting of caribou has been prohibited in the entire study area since 1978. Our information suggests losses to poaching are very small and may average less than an animal per year. On average, probably two or three caribou are killed on Highway 16 by vehicles. These losses occur primarily in early spring and in late fall. We have only two reports of collision losses from the railroads but others have likely occurred. The most serious occurred on January 9, 1982, when two separate bands totalling 17 animals were killed between Sinclair Mills and Dome Creek during a horrendous snowfall. This may have represented a quarter to a third of the caribou population in the Bearpaw Ridge area at that time. A new group has yet to re-establish itself in the Redmountain Creek area where one of the two decimated bands once resided.

Predation is likely the main cause of mortality and is likely the factor limiting population growth. While we have several reports of adult caribou being killed by predators, we have no reports of predation of calves yet the calves are disappearing. During our flights in February, 1984, 18 of 110 (16.4%) caribou seen were calves and in March, 1985, 13 of 107 (12.1 %). The entire study area has low to moderate populations of wolves, grizzly bears and black bears. Wolverine are also widespread, while coyotes are found in a few areas. Golden eagles are widespread in the summer months.

Grizzly bears and wolves are probably the main predators of calves. Grizzly bears are not uncommon in the subalpine forests at calving time and I have occasionally seen them or their tracks up to treeline. Wolves occur but not as regularly as grizzly bears. Wolves use the subalpine and alpine more frequently in the summer months. Wolverine are present but relatively rare. Calves born at lower elevations could also be predated by black bears or coyotes. All of these predators likely take both calves and adults through the summer months and early fall.

The coming of snow in the fall, while it makes food harder to find, probably brings considerable relief from predation. I have found no evidence of predation from early winter until February among those caribou that stay at higher elevations. The caribou are protected by the soft snow which normally persists at that time. However, once there is a major thaw -usually in February- then wolves again ascend to the subalpine and alpine to hunt. Caribou which spend most of the winter at low elevation or cross lowland valleys during the winter are occasionally killed by wolves. In those winters when there is little snow or the snow conditions are such the caribou are forced to lower elevations, the entire population is likely more vulnerable to predation.

The Impacts of Man

The activities of man in the study area have altered the forest habitat used by caribou and continue to do so. Without question forest harvesting has had the greatest impact but major transportation corridors, settlements, and agricultural developments have also caused significant impacts. Logging appears to have isolated the caribou on George Mountain and in the Narrow Lake areas from each other and from the populations in the Cariboo Mountains. Logging, the transportation corridors and agricultural land development appears to have increased the separation of the Cariboo Mountain and Rocky Mountain populations. Nevertheless, I do not believe these activities of man, except in one area, are presently causing any decreases in numbers of caribou. Overall, there appears to be much more suitable habitat than current populations require or will require for many years to come. The possible exception is in the Bowron River - Haggen Creek area where virtually all forest below 1250 m is being removed as a result of spruce bark beetle attacks. Until 1983, the area was used extensively by caribou.

In some areas, access development associated with logging and other activities may be leading to as much impact on caribou numbers and their distribution as the changes to their habitat. A few animals are being lost to collisions and poaching but the main impact is unintentional harassment. There are several areas which are largely avoided by caribou, especially in winter, due to extensive use by recreationists. For example, few caribou remain on Teare, Mica and Bell Mountain areas near McBride where there is good access and heavy use by snowmobiles but good alternate caribou habitat is scarce. Heli-skiing operations in the Canoe River area appear to have caused the caribou to largely avoid it. The caribou appear to be avoiding the Raven Lake area in winters when logging has permitted cross country skiers good access. We are seriously considering imposing restrictions on snowmobile use of the Bearpaw Ridge in order to minimize harassment. The problem of incidental harassment is likely to grow as access improves and more people want to recreate in the mountains in the winter.

SUMMARY

I believe the caribou population in most of the study area is currently healthy and, overall, may be increasing. There appears to be plenty of habitat in most of the study area to support a larger population. The exceptions are the Cariboo Mountains southeast from Dome Creek and George Mountain. In both of these areas good caribou habitat appears to be relatively scarce and it is being logged or heavily used by recreationists.

Prior to 1978, I believe the reported caribou decline was real and it was the result of excessive hunting in addition to all other sources of mortality. We have considered re-opening controlled hunting but are hesitant to do so because of low recruitment and uncertainty of the impact of other activities of man. To manage the caribou and appreciate the impact of logging and other developments, we could use much more information not only on habitat relationships with particular emphasis on the role of snow, but also on populations. We hope the studies currently in progress in the Quesnel Highlands, the Revelstoke Dam area, Alberta and elsewhere will provide some answers. We do not have the resources for an intensive study nor can we justify one in light of other priorities.

We could use better inventory as we have almost none for half the study area. Even in the McGregor and north Cariboo Mountains better data is desirable. These two areas should be monitored closely to determine the full impact of the recent widespread logging. Regardless, we will continue to observe and monitor the caribou using whatever resources we can and time we can spare.

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2.4 TWEEDSMUIR CARIBOU HERD

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Introduction

The northern Tweedsmuir Caribou Herd historically numbered perhaps as high as 1,000 animals in the 1950's and early '60's but more recently was estimated at 500 animals. In response to perceived declines, hunting was closed in 1978 and opened again on a limited entry basis in 1982. A Parks Branch report (Hatter 1979) collated all known information regarding seasonal distribution, and population dynamics and offered various scenarios for past population fluctuations. Loss of winter habitat east of the Park was identified as one of the most serious threats to the existing herd. Importantly, it identified five (5) objectives of any future study. They were:

- a) to identify winter ranges and specific habitat types selected
- b) to determine migration routes
- c) to document summer and fall distribution
- d) to collect population dynamics data, and
- e) to assess predator densities and activity within the study area.

Present

In response to recent approval by the Ministry of Forests to allow logging activities east of the Park, the Ministry of Environment in co-operation with the Burns Lake and District Guide-Outfitters and the Tweedsmuir Rod and Gun Club, initiated an aerial monitoring program of radio-collared adult caribou in the Tweedsmuir Park areas. The objectives were virtually identical to those suggested in the 1979 Parks Branch report. Nineteen adult females, while crossing Tetachuck Lake during the fall migration had Telonics Configuration 5B radio collars attached. Fixed wing aerial monitoring commenced in November, 1983 and approximately 300 relocations have been made (to September 15, 1985). Habitat type, location, elevation and aspect are recorded on each flight. Two helicopter flights have been undertaken to determine herd productivity and one for a feeding site inspection. General information has now been gathered regarding seasonal distribution, habitat selection, migration routes, calving areas, rutting areas and calf survival. Predator density information has not yet been gathered.

Study Area

The study area encompasses approximately 10,000 km² in the south-east portion of the Skeena subregion and is bounded by the Coast Mountains on the west, Ootsa Lake on the north, the Fawnie Range in the East and the Blackwater River on the south. Terrain is mountainous in the west and gradually becomes rolling lowlands interior forest towards the east. Alpine areas are found on the Fawnie, Quanchus and Chickamin Range and are generally above 1600 m above sea level. The area is characterized by cool summers with frequent local storms as a result of air flows from the Pacific Ocean. Reduced winter snow depths occur as one moves from west to east. Lodgepole pine and aspen pioneer extensive seral stands and occur primarily in the eastern portion of the study area. Spruce and subalpine fir occur extensively at higher elevations in the east (Fawnie Range) and throughout much of the western portion of the study area. The pine-lichen ecosystem association of the Sub-Boreal Spruce Zone is found in the Entiako-Johnny-Laidman Lakes area and is considered of primary importance in the forestry/caribou issue.

Access is restricted to boat and aircraft in the Park portion of the study area while new road access is now provided by the Chelaslie main haul road and the Kluskus Forest Development Road south of Vanderhoof. The Kluskus-Malaput Road is being built and will possibly connect through to Anahim.

Results

Seasonal distribution is characterized by a shift in the late fall and early winter from Tweedsmuir Park in the northwest to the Entiako River drainage in the southeast apparently in response to increasing snow depths. (Figure 3). The shift generally starts in mid-October and by the second week of November most of the animals have crossed Tetachuck Lake and can be found in the Entiako River drainage. It appears that adult females set the timing and direction of the migration and that later groups tended to follow, intermittently, those trails of earlier groups.

In the winter of 1983/84 approximately 60% of the herd utilized the Laidman-Johnny Lakes area from mid-December until late February. Four collared animals remained in the Entiako River drainage. In the winter of 1984/85 all collared animals reached the Laidman Lake area by early December and the last animal departed in early April. Approximately 95% of all re-locations between December, 1984 and the end of February 1985, are found in the vicinity of Laidman Lake. (Figure 3). Mature pine stands under which there were heavy loads of terrestrial lichens were used extensively. Arboreal lichen use was not noticed.

The spring of 1984 was several weeks earlier than in 1985 and was more prolonged; i.e. daily temperatures remained generally cool for approximately one month. As a result the Pine flats at the mouth of the Entiako River was the first area to become snow-free. On March 7 all collared animals were found here. In 1984 the collared animals migrated from the mouth of the Entiako River to the west crossing either Euchu Reach or Tetachuck Lake. It was noted that the only open water was at these 2 areas. It also appears that due to the distribution of snow, the herd utilized the Chelaslie River floodplain as a major migration route towards the Park.

In 1985 the spring migration from Laidman Lake was characterized by a more lengthy and scattered distribution towards Tetachuck Lake. Animals began dispersing in early February and the last animal did not leave the Laidman Lake area until mid-April. Spring melt occurred several weeks later than in 1984 and was not as localized. Melting occurred quickly and resulted in snow free areas throughout the Entiako drainage. It also appeared that the animals concentrated on the south shore of Tetachuck Lake before swimming the lake; perhaps in anticipation of open water.

Dispersal into the Park was similar in 1984 and 1985 (Figure 3). It appeared that those areas that are exposed to prevailing winds from the west become snow free earliest. These areas are the two valleys containing Glatelli and Fenton Lake and the north shore of Eutsuk Lake. Animal relocations in 1984 and 1985 in May were in these areas. Generally, deep snow was encountered in the alpine and subalpine in May of each year.

By calving time (Figure 4) in early June the collared females were widely distributed and utilized both low elevation mature pine/spruce stands between 900 and 1350 m and alpine areas at elevations of up to 1850 m. In 1985, 5 of 6 females observed at low elevation did not have calves at heel; whereas 3 of 4 females seen in the alpine had calves.

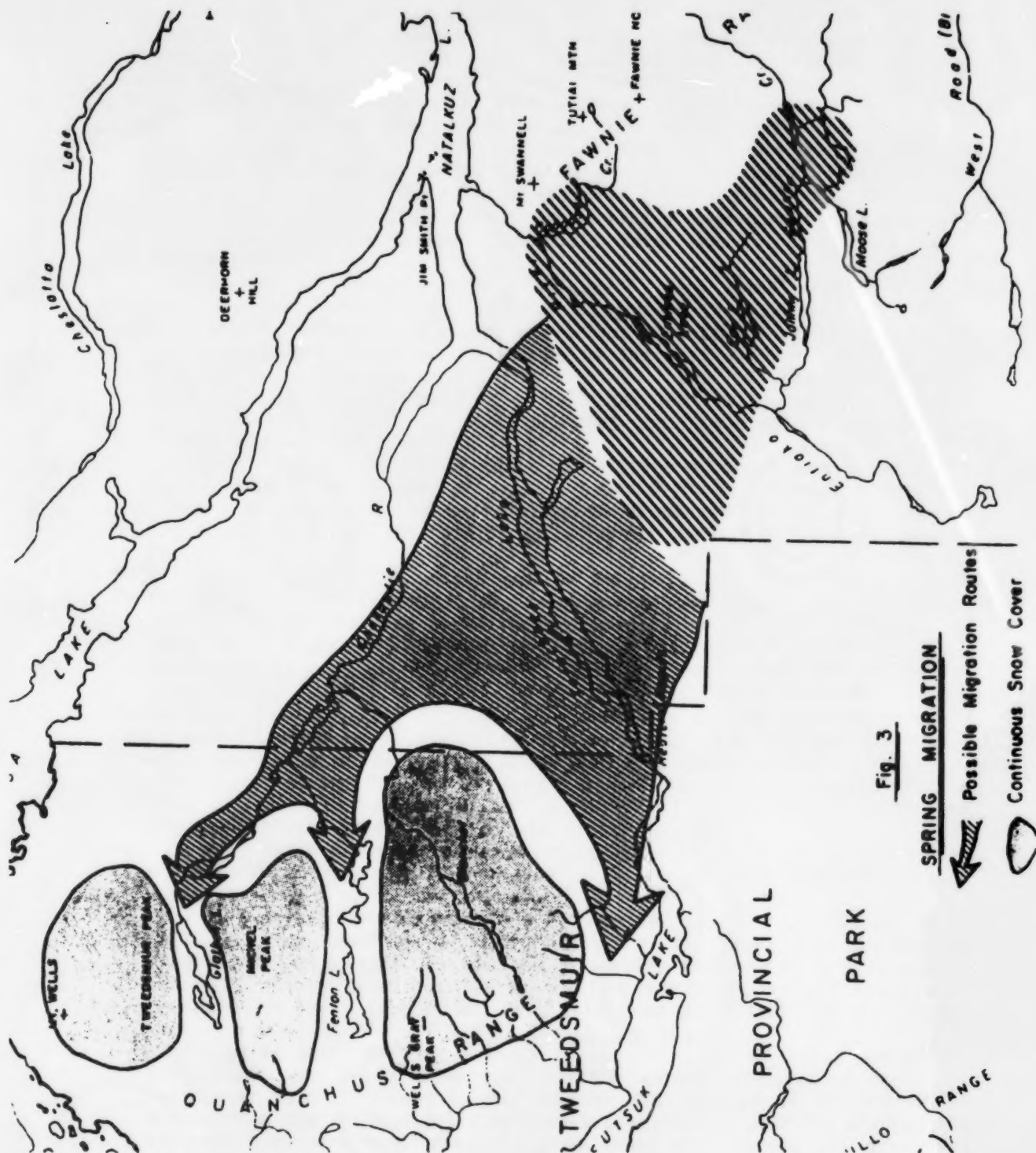


Fig. 3

SPRING MIGRATION

➔ Possible Migration Routes

◐ Continuous Snow Cover

Figure 3. Spring migration from winter range in the east to Tweedsmuir Park.
NOTE - There are no figures 1 and 2.

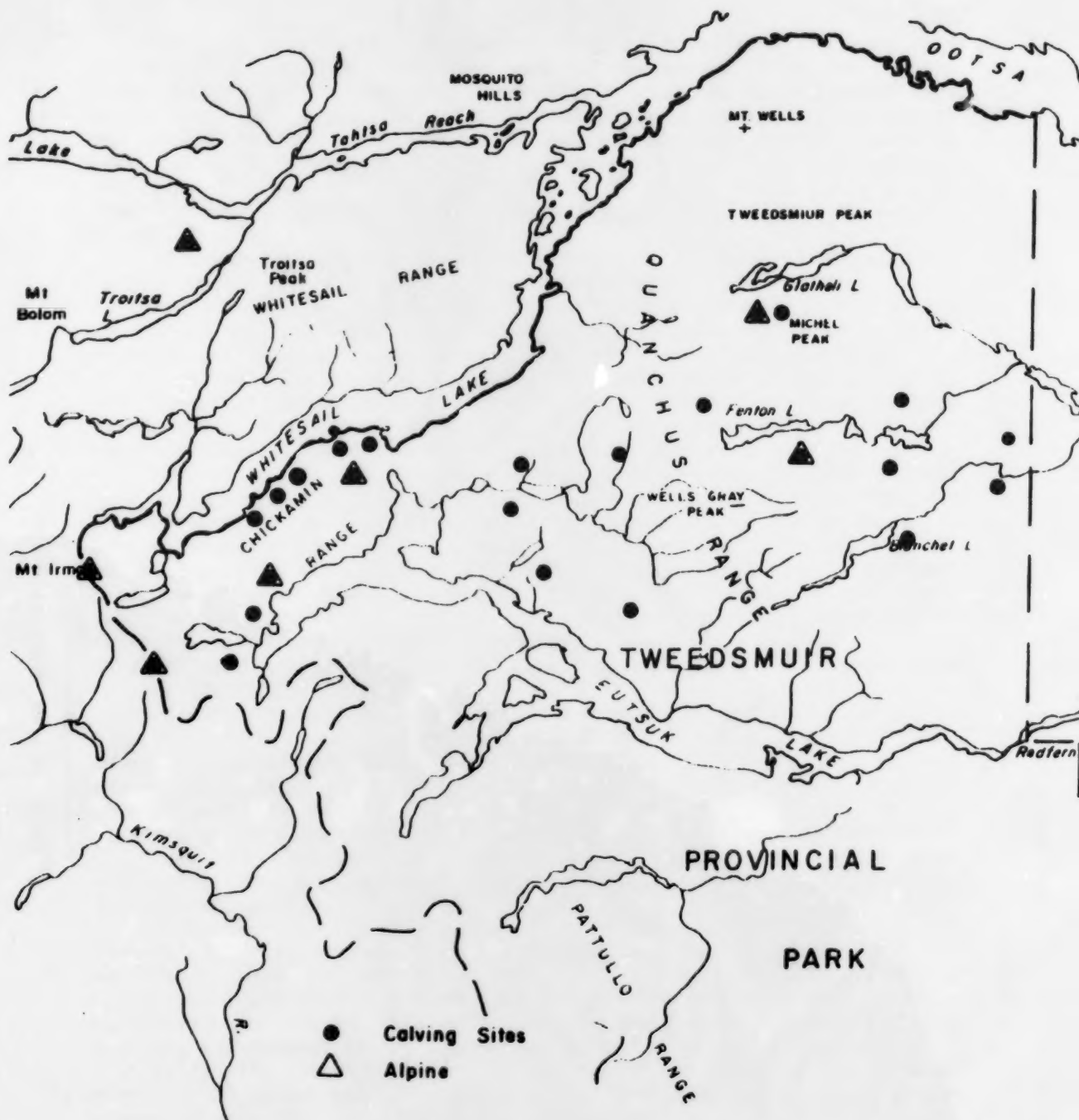


Figure 4. Calving locations in June.

It was noted that calf affinity to the females was very strong at this time. Affinity to calving areas by the collared females appears to be strong with 6 females returning to within 3 km of the site used the previous June. Two animals were 8 and 60 km respectively away from the area utilized the previous year. We do not have information regarding the affinity to calving areas between pregnant and non-pregnant females.

Summer snow patch use in 1984 occurred with a minimum of 98 caribou seen; of which one had a collar. In 1985 the relatively hot dry summer did not appear to result in increased snow patch use and in fact no animals were observed in the alpine despite numerous flights by the Ministry of Forests, the Parks Branch and guide outfitters. Throughout the summer and fall animals remained generally in mature forest habitats with some movement towards the Nutli Lake area occurring by early September.

By the rut in early October (Figure 5) many animals had moved from the Chickamin Range to the central portion of the Park and were found utilizing a variety of habitats at various elevations. A large group of 155 caribou was found in the alpine on the west flank of Michel Peak. Four collared females were in this group. Due to very poor weather conditions, a rough estimate of 27 bulls per 100 females and 9 calves per 100 females was found. It is likely that the female estimate contains a number of the younger aged bulls.

The first two suspected adult mortalities occurred during the early spring with either wolves or grizzly bears being implicated. Two radio collars are suspected to have failed to date and one collar is on the ground at St. Thomas Lake and it is not known whether that animal slipped the collar or died.

Herd productivity, as measured by the number of calves surviving and the number of adult mortalities, suggest that the herd is declining. Of the 10 females observed by helicopter in June, only 4 had calves and of these 4, 3 apparently did not survive until October. One female which had a calf in June was not observed in October due to poor weather conditions and it remains to be determined whether her calf survived. Of the collared females alive in June all remained alive until early October. It therefore appears that calves had a mortality rate that may exceed 90% while adult females may suffer approximately a 15-20% mortality rate.

A preliminary look at the herd's annual home range suggests that an area of approximately 2,000 km² is utilized and contrasts with the 100 km² utilized in the Laidman Lake wintering area.

Mean daily movements show two peaks. The first is during the spring migration and the second coincides with the rut and movement to the wintering area.

Quantifiable predator density information is lacking although it is felt that low densities of wolves occur in the study area during the winter. Grizzly bears are spotted frequently during the spring, summer and fall within Tweedsmuir Park. Guide outfitters report heavy wolf predation in early fall as the herd shifts to the eastern portion of the park.

Logging activity in the study is occurring in two areas and extensive plans are being developed for the entire study area excluding Tweedsmuir Park. Present plans are for the removal of 300,000 m³ of timber from the north side of Tetachuck Lake, and 17,000,000 m³ from the Entiako River drainage area. Logging roads will access all areas and will provide access from Vanderhoof to Anahim Lake. Localized over-

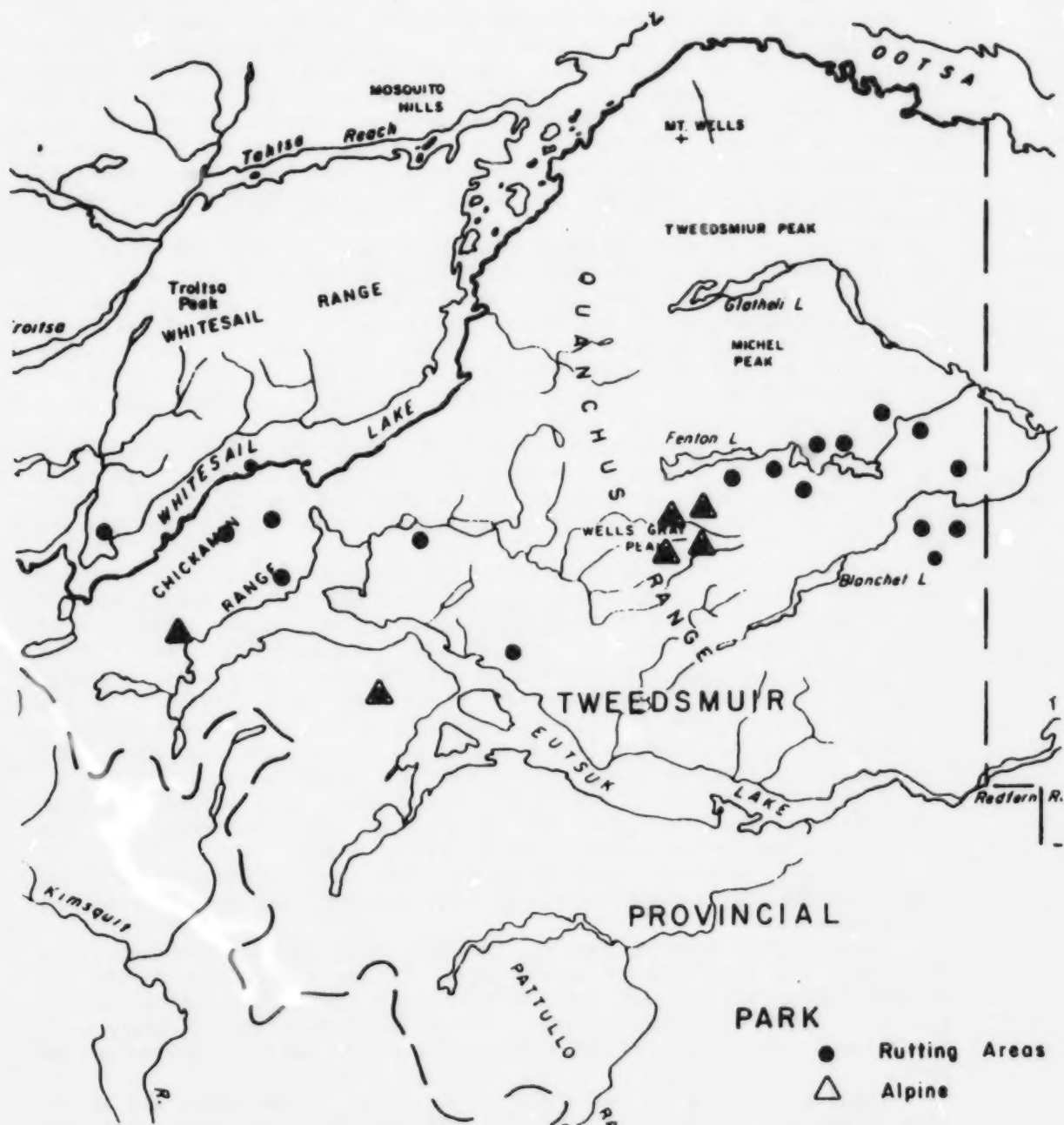


Figure 5. Rutting locations in October.

harvests of moose have occurred and poaching of caribou is expected to increase. Snowmobile disturbance of caribou has been documented. Present data does not allow us to formulate realistic habitat protection guidelines although an industrial activity closure was agreed to with the Ministry of Forests for the period of the caribou migration in the vicinity of Tetachuck Lake in the fall. For the most part, this activity closure was apparently not adhered to by the local forest licensee. It is surmised that direct habitat loss in many portions of the study may not adversely affect the caribou due to their temporal distribution throughout the year. The secondary effects of direct harassment, disturbance, poaching by humans, and increased predation may more adversely affect the herd. The removal of access to certain habitats such as the alpine and subalpine portions of the Fawnie Range or wetlands may be critical.

Funding for this project has been on an ad hoc, "nickel-and-dime" basis and future funding is not guaranteed. Section 88 funding in the amount of \$23,000 was recently approved; the Habitat Conservation Fund board is undecided as to whether this type of project falls within their guidelines; the Public Conservation Assistance Fund was used to obtain \$9,000; the Parks Branch has been the main contributor at about \$20,000 and Wildlife Habitat Canada is now being approached for \$130,000. Future work will emphasize winter habitat requirements, predator/prey relationships and the effects of human caused disturbance on caribou distribution and their use of habitats.

Summary:

- 1) It appears that the herd is declining with wolf and grizzly bear predation implicated but not proven,
- 2) use of habitats in the spring varies from year to year in response to snow melt,
- 3) the use of certain areas as a migration corridor also varies from year to year in response to snow melt,
- 4) straight-line distances from wintering areas to calving areas may exceed 150 km,
- 5) non-winter habitat selection varies widely while winter habitat use appears to key into mature pine stands with a terrestrial lichen carpet,
- 6) industrial development is scheduled for all areas that the herd occupies except Tweedsmuir Park, and
- 7) future work will emphasize winter habitat requirements, predator information and the development of a Caribou/Forestry Area Management Plan.
- 8) Population estimates are hard to obtain as the herd spends a majority of the time below treeline.

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2.5 CARIBOU IN THE ITCHAS AND ILGACHUZ: A SUMMARY OF HARVEST, INVENTORY AND OTHER INFORMATION*

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SUMMARY

Prior to 1977, virtually all reconnaissance on the Itcha-Ilgachuz caribou (Rangifer tarandus caribou) herd was related to sightings during flights to or from Bella Coola and the Dean River or on moose surveys. However, as resource demands (logging, mining, hunting) increased, so did the need for detailed management information.

In the past, this herd received extensive management and hunting was the only demand placed on it or the habitat. Logging was a minor concern as low value timber and high transportation costs precluded harvesting. Cattle grazing was pre-empted after a short duration to protect the high wildlife values (Appendix A). Significant quantities of minerals had not been located.

This is currently changing; large amounts of winter range have been impacted by the mountain pine beetle and are slated for removal. Also, the Ilgachuz have been staked for minerals and it is likely the Itcha Mountains will be staked by the end of 1986.

A winter survey conducted in 1977 established a minimum of 350 caribou. The present estimate of 1200-1400 is due to a real increase in the period 1977-1985 and as a result of more intensive surveys.

A radio-telemetry program (6 caribou) was initiated in August 1982 to obtain basic information on seasonal migration patterns, home ranges and other critical habitat and population factors. In October 1984, an additional 11 caribou were radio-collared and in November 1984 up to 13 others were ear-tagged and/or neck collared during a transplant program, allowing collection of more detailed information on movements and habitat use, as well as facilitating the improvement of population estimates.

Hunter-harvest levels have varied during the last twenty years. Until the mid-1960's, harvest was largely uncontrolled. Due to the remoteness of the area and relatively low number of hunters, a long either-sex season produced an acceptable harvest, mostly by non-residents. In the late 1960's a possible overharvest occurred but data are inconclusive. Eventually, as access and harvest increased, more regulations were instituted to prevent overharvesting.

* Extracted by the editor from Smith, T.R. and D. Hebert. 1987. Caribou in the Itchas and Ilgachuz; a summary of harvest, inventory and other information. Wildlife Bulletin B-??, Wildlife Branch, Victoria, B.C..

Predation does not appear to be a problem at this time but there is potential for an explosion of the wolf population.

Other big game species present in the area are moose, sheep, grizzly and black bears including a recent sighting of a mountain goat in the Ilgachuz.

CONCLUSIONS

1. Bergerud (1978) suggested that caribou migrated from the Ilgachuz to the Rainbows to calve. While this has been proven to be incorrect, movement between these three systems (Itchas, Ilgachuz, Rainbows) has been confirmed. It appears movement between the Rainbows and Ilgachuz varies from approximately 20 to 200 (D. Cichowski, pers. comm.) and could be impacted by development of the Dean River valley.
2. Results of the replicate flights are heartening. Previous inventories have had no checks as to their precision or accuracy. Given the potential that virtually all caribou in the alpine can be inventoried and an indication that the percentage of caribou in the alpine can be obtained, population estimates can be improved and variance narrowed. Estimating bulls will continue to be a problem however, as only two are visually marked and do not provide a sufficient sample size. Other problems are the time period in which these animals have been marked and whether all marked caribou are, in fact, in this area. It is certainly possible that not all caribou from the transplant returned to their native range.
3. The caribou that winter in the alpine, specifically on the north slopes of the Ilgachuz, are of interest. The wind action removes the snow and exposes lichens and other food, however no use of other apparently similar wind-swept areas occurs. This use may be directly related to movements between the Rainbow and Ilgachuz mountains.
4. The potential removal of winter range by logging is of concern for three main reasons:
 - i) Lichens: Arboreal lichen growth and dispersal are slow and associated with mature forests. In general, the older the tree, the more lichen and litterfall associated with it. Growth is affected by moisture and sunlight (Stevenson 1985) both of which can be indirectly affected by logging.

The effects of logging on terrestrial lichen, which may well be more important than arboreal lichens to caribou, are unknown. Terrestrial lichens may grow on dry sites resulting from logging. However, at this time it is unknown how dry a site can be before growth is enhanced or reduced.

- ii) Predation: As areas are logged, caribou use will likely be confined to fewer areas which may result in higher predation. If caribou are unable to disperse and are concentrated in pine stands, predation could become significant. Also, shrub production may increase allowing the moose population to increase. This will provide more alternate prey and may result in an increase in wolf density and numbers.
- iii) Access: History has shown that with an increase in access, there is usually an increase in harvest, legal and illegal. The Wildlife Branch regulates the legal harvest but it is extremely difficult to control the out-of-season kill. More roads require more enforcement effort to reduce the illegal kill.

At this point, the benefits of leaving beetle killed forests are unclear. Access would remain limited and not all trees would be killed. Lichen production would continue on live trees and possibly on snags. One thing is certain; after logging, arboreal lichens will not be available for several decades.

- 5. Historic harvest may have been excessive. Population estimates were virtually non-existent and total harvest prior to compulsory inspection is suspect. Hunting regulations appear to have caught up with effort and access. The present goal of maintaining a quality harvest of 30-35 trophy bulls from a population of 1200-1400 caribou is appropriate. A limited cow harvest to obtain samples would likely be a possibility in the future.
- 6. The potential for a population crash by predation appears imminent. There is a good prey base (caribou), a good alternate prey base (moose), and a source of predators. The Wildlife Branch has asked locals what reasons there are for low densities of predators in this area, however, no rationale has been given.

RECOMMENDATIONS

- 1) More research into caribou biology is necessary. Some questions that need to be answered are:
 - a) How important are terrestrial lichens to caribou?
 - b) Can caribou survive on only arboreal/terrestrial lichens?
 - c) Will snow patterns in cutover areas eliminate terrestrial lichen feeding?
 - d) Can arboreal/terrestrial lichen production be enhanced?
 - e) Can more caribou winter above treeline?

- f) Are bug-killed forests of any value to caribou?
 - g) What effect does fire have on terrestrial lichens?
 - h) What is the maximum caribou population attainable?
 - i) Is the area north of the present winter range potential winter range?
- 2) A wolf management policy be established for this area. Even though several species of predators are present, the wolf presents the largest threat to the maintenance of the caribou.
- 3) A forest management policy that recognizes the importance and uniqueness of this area should:
- a) reduce the Annual Allowable Cut through the Timber Supply Area analysis,
 - b) support the current Wildlife Management Area proposed by the Ministry of Environment.
- 4) Mapping of caribou winter range by radio relocations, habitat types and lichens continue.
- 5) Logging development plans be directed away from known wintering areas until more information on caribou use is known.
- 6) Motorized access be controlled. Snowmobiles and A.T.C.'s using seismic lines and open forests have great potential for disturbing caribou. Restrictions should be implemented before problems arise.

UPDATE ON HARVEST

With the new 5 point bull regulation instituted in 1985, the harvest was significantly reduced. In 1983, 56 bulls were harvested; in 1984, 47. The legal harvest in 1985 was 19 with the average age being 5.0.

It is expected as hunters become accustomed to the regulation and the younger bulls are afforded more protection, the age and number of bulls harvested will increase.

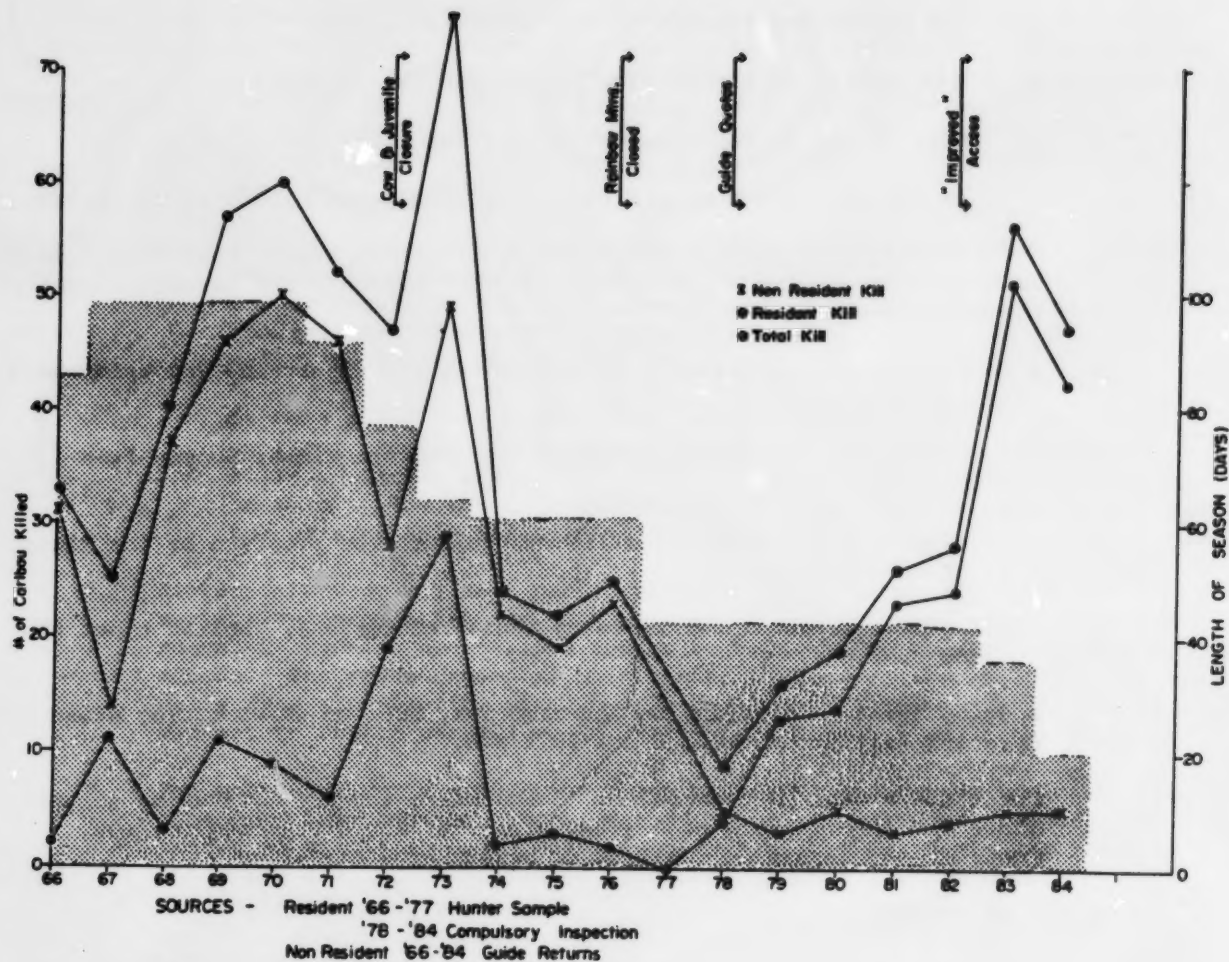


Figure 1. History of hunting seasons in the Itchas-Ilgachuz caribou herd.

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2.6 WINTER HABITATS OF MOUNTAIN CARIBOU IN THE NORTH THOMPSON

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Winter (November to April) habitat use distribution of mountain caribou in the North Thompson was found by earlier researchers to span a wide altitudinal range, from valley bottoms to alpine (Edwards and Ritcey 1959, Ritcey 1974). This distribution encompassed the Interior Cedar Hemlock (ICH), Engelmann Spruce - Subalpine Fir (ESSF), and Alpine Tundra (AT) biogeoclimatic zones (Krajina 1965, Lloyd 1983). In the late winter (January to April), most of the caribou observed were occupying mature ESSF forests mostly above 1400 to 1500 m, where they fed on arboreal lichen (Alectoria sp., Bryoria spp.) range. Much of this use was located above 1680 m (5500 ft). Accordingly, the B.C. Fish and Wildlife Branch (Ritcey 1978, 1979) proposed that in areas designated as caribou winter range, mature ESSF forests above 1680 m should be protected from logging, as a measure toward ensuring critical arboreal lichen range. This presentation outlines recent results into the general pattern of winter habitat use by mountain caribou in the North Thompson. Most emphasis is devoted to the degree of late winter use above or below 1680 m, as a primary concern is the adequacy of the proposed upper subalpine, mature forest reserve.

Winter distribution of caribou over the winters of 1978-79 and 1979-80 was determined by radio telemetry of up to four caribou bands, supplemented by ground and aerial observations of other caribou bands. The core study area was located in the Kamloops Timber Supply Area immediately south and east of Wells Gray Provincial Park. The ESSF forested areas above 1680 m were classified as the upper subalpine, while those below this elevation, down to 1350 m, were identified as the lower subalpine. The areas below 1350 m were classified as ICH habitats.

Altitudinal migration and habitat distribution of North Thompson caribou essentially paralleled that described earlier for this area by Edwards and Ritcey (1959). Altitudinal migration, from high to low and reascending to high elevations, occurred twice during the annual cycle. Over the late spring to early fall (June to October), caribou were distributed from the lower subalpine up to the alpine. From late fall to early winter (November to January), as snowpacks on summer ranges deepened, caribou descended to early winter range distributed from the lower subalpine down to the ICH forests, i.e., to mid and low elevations. Firmer mid winter (January or February) snowpack conditions allowed caribou to reascend to the higher elevation habitats, i.e., to mid and high elevations. Throughout the winter caribou predominantly occupied mature forested areas (i.e., forest cover map age classes 8 and 9, forests > 140 years old). In early spring (late April and May), caribou descended to snow free, ICH habitats, before reascending once again by late spring (June).

Caribou winter movements, habitat use and forage use patterns appeared related to climatic conditions, particularly to snow as it affected food availability and locomotion conditions.

The early winter move to mid and low elevation forests was associated with a shift to shallower snowpack depths, and thus to areas of both better mobility conditions and greater availability of terrestrial forages. As snowpack conditions permitted, the diet and foraging behaviour of caribou was diverse. Caribou cratered through softer and shallower snowpacks for forages in the herb and lower shrub vegetation strata, browsed shrubs protruding above the snowpacks, and grazed both arboreal alectoroid and arboreal foliose lichens from litter fall and standing, windfallen or logger felled trees. These lower elevation forests appeared to be the most energetically economical areas over the early winter period of rapidly accumulating, soft (poorly supportive) snow.

Arboreal lichen availability in the forest canopy was low in all habitats during much of the early winter because snowpack depths were generally still too shallow to allow caribou to forage higher on trees where lichen was more abundant. Nevertheless, arboreal lichens were readily eaten where available, and their availability in part contributed to the heavy use of mature forests by caribou at this time. However, since the early winter habitats of caribou were essentially below the upper subalpine, the proposed mature forest reserve would be of little benefit to caribou in this period. Instead, mature or near mature forested areas in the ICH and lower subalpine must be provided as early winter range. This need was recognized by earlier researchers (Edward and Ritcey 1959, Ritcey 1974).

Over the late winter, caribou occupied upper and lower subalpine habitats, using them both as arboreal alectoroid lichen range. Alectoroid lichens on standing trees were the predominant late winter forage and forage source, respectively. Both subalpine ranges effectively offered much greater amounts of available lichen than did the lower elevation, early winter habitats. As pointed out by Edwards and Ritcey (1959) and Edwards *et al.* (1960), deepening snowpacks resulted in a steady increase in the availability of arboreal lichens. This was especially evident in the subalpine where snowpacks were quite deep by mid winter and continued to accumulate through the late winter. It is important to note that in late winter, arboreal lichens were relatively most available in the upper subalpine, and thus it could be assumed that this habitat was a better foraging range than the lower subalpine.

However, another factor of importance to caribou was the mobility conditions in snow. As noted earlier in this presentation, as well as observed by Edwards and Ritcey (1959), mid winter settling of the fresh and soft early winter snow accumulations coincided with the caribou's ascending migration to subalpine arboreal lichen habitats. Once within these higher elevation habitats, the caribou subsequently experienced cycles of fresh snow depositions and worsening mobility conditions, followed by settling and improved mobility conditions. It is important to note that the upper subalpine, although

offering the most available arboreal lichen, was often characterized by poorer mobility conditions than the lower subalpine.

The proportion of caribou use in the upper subalpine among two week snow-sample intervals in the late winter ranged from approximately 40 to 100%, with the lower subalpine essentially accounting for the remainder of caribou observations. In this period the degree of use of the upper subalpine fluctuated in an inverse association to general trends in caribou mobility conditions in snow; when mobility conditions deteriorated, caribou utilization of the lower subalpine increased. In comparison to the upper subalpine, the lower subalpine was more protected. It was more densely timbered and thus offered more shelter from accumulating snow or worsening mobility conditions. It was also usually located in less topographically exposed locations, and thus, along with the denser forest cover, possibly offered improved shelter from strong winds or other severe weather conditions.

The use of the lower subalpine in the late winter, therefore, may not have been a casual option for caribou. Instead, it appeared that the lower subalpine periodically was an important refuge from less tolerable weather or mobility conditions at the higher elevations, in addition to essentially being a continuous component of the caribou's late winter arboreal lichen range. The results of this study suggest that it is unwise to assume that the upper subalpine forest is solely adequate as late winter arboreal lichen range. It appears that careful consideration must be given to ensuring that late winter range also includes mature forested areas in the lower subalpine.

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2.7 THE EFFECTS OF SNOWMOBILING ON WINTER RANGE USE OF MOUNTAIN CARIBOU

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ABSTRACT

Aerial observations of caribou winter range areas showed that caribou avoided areas where there was extensive recreational snowmobiling. Experimental disturbance of caribou, using one or two machines, showed that human scent and large groups moving rapidly around an area were the main causes of avoidance by caribou. Caribou could tolerate low levels of snowmobile use. Recommendations included reducing snowmobile use by access and group size restrictions and posting information signs informing snowmobilers to avoid areas where there were caribou or tracks.

INTRODUCTION

Snowmobiling is a valid recreational activity which promotes appreciation of and familiarity with remote areas. Snowmobiles are also an important tool for trappers and others who work in snow covered areas. With the increasing use of snowmobiles, it is important to ensure that they do not have detrimental effects on wildlife populations.

Little information exists on the response of mountain caribou (Rangifer tarandus caribou) to human disturbances. Some information is available on the response of northern caribou to vehicles, aircraft and construction activities, and there is considerable data on the responses of deer to snowmobile use on their winter ranges.

Klein (1980) concluded that manmade linear features such as roads, railroads, pipelines, powerlines and artificial water courses block, deflect or delay caribou movements. The level and type of vehicle traffic and other human activities associated with these features influenced the reaction of caribou. Caribou avoid unfamiliar stimuli but, if these are found to be benign, they learn to ignore them (McCourt et al. 1974). Some activities, such as logging, actually attract caribou during periods when alternative foods are in short supply (Simpson et al. in prep.) The response of caribou to human activities depends on the animals' previous experience and may vary from flight to habituation (Geist 1971).

The literature for deer is inconclusive. Some report that snowmobiling caused no changes in range, movements or population size of deer (Aune 1981, Eckstein et al. 1979). Others found increases in range and abandonment of high use snowmobiling areas (Dorrance et al. 1975, Kopischke 1972). Snowmobile use in some deer habitats may be beneficial in providing easy travel routes between feeding sites on packed trails (Richens and Lavigne 1978). Deer, elk and bison, in Yellowstone Park adapted to snowmobile use by avoiding high use areas

during the day and using them at night, when snowmobiles were not present (Aune 1981). Their dependance on snow-free geo-thermal areas for winter food and the lack of alternative feeding sites probably forced this adaptation. The varying results suggest that the circumstances surrounding each study area were important in determining the reaction of deer to snowmobiling.

Caribou have the largest home range of any North American ungulate. Most researchers believe that caribou travel so much more to find optimum habitat (snow and forage) conditions that are spatially separated (White et al. 1981) and to maintain spatial separation from predators (Bergerud et al. 1974). Movement and habitat use by caribou varies in different parts of North America but the requirement for space is universal.

Concern about snowmobile use on caribou winter ranges stems from the possibility of disturbance causing losses of useable range and affecting reproduction and survival. Disturbance can cause delayed death in large mammals (Young and Bronkhurst 1971) or disruption of cow-calf bonds and increased calf mortality (Shea 1979). Losses of range lead to reduced abundance by making caribou more vulnerable to their natural predators (Bergerud et al. 1984) and by increasing the cost of obtaining food.

The purpose of this study was to determine:

1. Does snowmobiling affect the range use of caribou in the Revelstoke area?
2. What factors were important in determining the response of caribou to snowmobiling?
3. What level of snowmobile use, if any, was acceptable to caribou?

ACKNOWLEDGEMENTS

This study was funded by the B.C. Ministry of Environment using funds provided by B.C. Hydro as partial compensation for wildlife losses resulting from the Revelstoke dam. The Revelstoke Snowmobile Club supported the voluntary snowmobile closures in portions of the study area. Guy Woods of the Wildlife Branch reviewed the manuscript.

STUDY AREA

The principal study areas were two alpine ridges near Revelstoke (Fig. 1). Both had rolling, moderately sloped crests in the Engelmann spruce (Picea engelmannii)-subalpine fir (Abies lasiocarpa) parkland forest zone at the 1830 m (6000 ft) elevation. The areas were characterized by mainly open terrain interspersed with clumps of trees. This forest type is the preferred late winter (Feb.-Apr.) habitat of mountain caribou (Simpson et al. 1985). Frisby Ridge was divided into three sections to assess caribou use in each. The southern section consisting of 13 km², was nearest the access route and

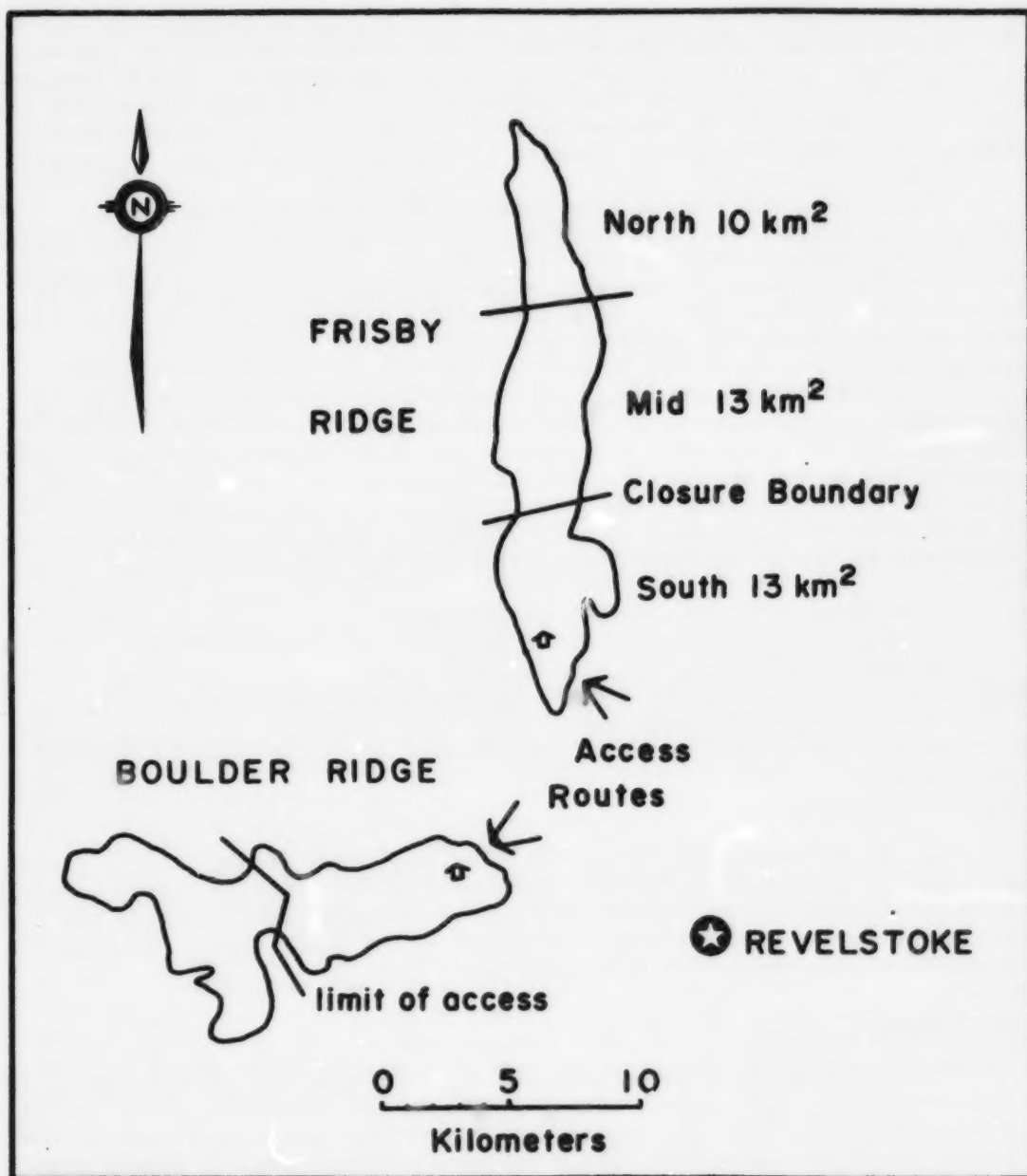


FIGURE 1. The study area showing the two alpine ridges near Revelstoke most frequently used by snowmobilers.

was most heavily used by snowmobilers. The central section was also 13 km² and was moderately used by snowmobilers. The northern section was smaller (10 km²) and was rarely used. The north ridge was burned about 1940 and only one-third of the area was forested.

Approximately one-half of Boulder Ridge and all of Frisby Ridge were accessible to snowmobiles when snow conditions were good. Generally, most use was restricted to the areas on the ridge tops nearest the points of access and decreased further from the access trails. Both ridges and logging road, then trails, provide access to their summits. A snow packing machine belonging to the Revelstoke Snowmobile Club was used to maintain access after heavy snowfalls.

Cabins were constructed on east Boulder in 1975 for snowmobilers and on south Frisby in 1975 for cross-country skiers. High elevation logging improved access to south Frisby in 1982 and a cleared trail for the snow-packer was established shortly thereafter.

METHODS

Caribou use on alpine ridges north of Revelstoke was recorded from 1981 to 1985 primarily for a habitat use study (Simpson *et al.* 1985). Snowmobile use was noted from 1981 to 1983 but was not consistently recorded or quantified. In 1984 and 1985, during weekly flights, areas of snowmobile activity were mapped. The number of machines using each area between flights or since the last snowfall was estimated from tracks. Snowmobile use on Frisby Ridge was also measured using sign-in sheets placed at an information sign near the snowmobile unloading site in 1985. Information requested included the date, address, number/group and time out.

The central and northern sections of Frisby Ridge (Fig. 1) were closed to snowmobiling by voluntary agreement with the Revelstoke Snowmobile Club. The area of the closure was indicated on the information sign, at the unloading site, and the boundary was posted on the ridge. Other users, particularly helicopter skiers, were also asked not to use the closed area.

Snowmobile disturbance was introduced to several other ridges, not normally used by snowmobilers, when aerial locations indicated that caribou were present and accessible. Animals were approached, but never chased, in five different areas. Their response was noted directly if the animals could be seen, or by tracking after they moved away. On two occasions radio telemetry equipment allowed us to track radio collared animals to determine their response.

Comparison of caribou use and movements in areas of varying snowmobile use were used to assess the effect of snowmobiling on caribou. Direct observation of the response of caribou to snowmobiles was helpful in understanding the aspects of snowmobiling that disturbed caribou.

RESULTS

Caribou use on Boulder Ridge was not well documented prior to 1983. However, Ron Humphrey, a private pilot from Revelstoke, had recorded caribou sightings in his flight log during eight flights in February and March between 1971 and 1974 (Table 1). Most sightings (63%) were in the meadow now occupied by the snowmobilers' cabin. In 1984 and 1985 only two caribou were seen in areas of Boulder regularly used by snowmobilers and none were seen in the meadow near the cabin. The snowmobile club members indicated that they seldom saw caribou or their sign on Boulder Ridge.

Caribou use on Frisby Ridge averaged 15 animals each year, however, there was a distinct shift in their distribution on the ridge from February to April based on aerial surveys (Table 1). From 1981 to 1983 most caribou were found at the south end of the ridge in February and gradually moved north (Fig. 2). By April, no animals remained on the south portion and their numbers again decreased to zero by April. Fifteen of the 21 animals seen in the south area were one group sighted 200 m south of the closure boundary. They were sighted the following day north of the boundary. The caribou distribution differed significantly before and after the closure ($\chi^2 = 100$, $p < .001$).

Forty-two percent of 76 observed users signed in on Frisby Ridge. I estimated 417 users from January 8 to April 15 based on the 175 sign-ins. Users averaged 5.5 hours per trip. Eighty-three tracks were counted past the closure signs (20%) but only 23 of these went more than 2 km past the closure (6%). Most (75%) were local users on weekends (82% Friday-Sunday). The two largest groups of 45 and 27, were people from Alberta, Saskatchewan, Nelson and Revelstoke.

Table 1. Historical and current caribou use on Boulder Ridge.

Years	No. flights	No. animals or tracks on Boulder	No. seen in other areas
1971-74	8	93	----
1984-85	13	16	1071

Snowmobile use on Frisby was quantified in hours per day based on questionnaire returns. Most use was in March or April (Table 3). Weather and snow conditions probably influenced the timing of use. Soft snow prevented access to the ridge since snowmobiles bogged down when climbing steep slopes. Dense cloud layers which frequently formed at 1400 m (4500 ft) created white-out conditions and made navigation on the rolling alpine terrain difficult and dangerous.

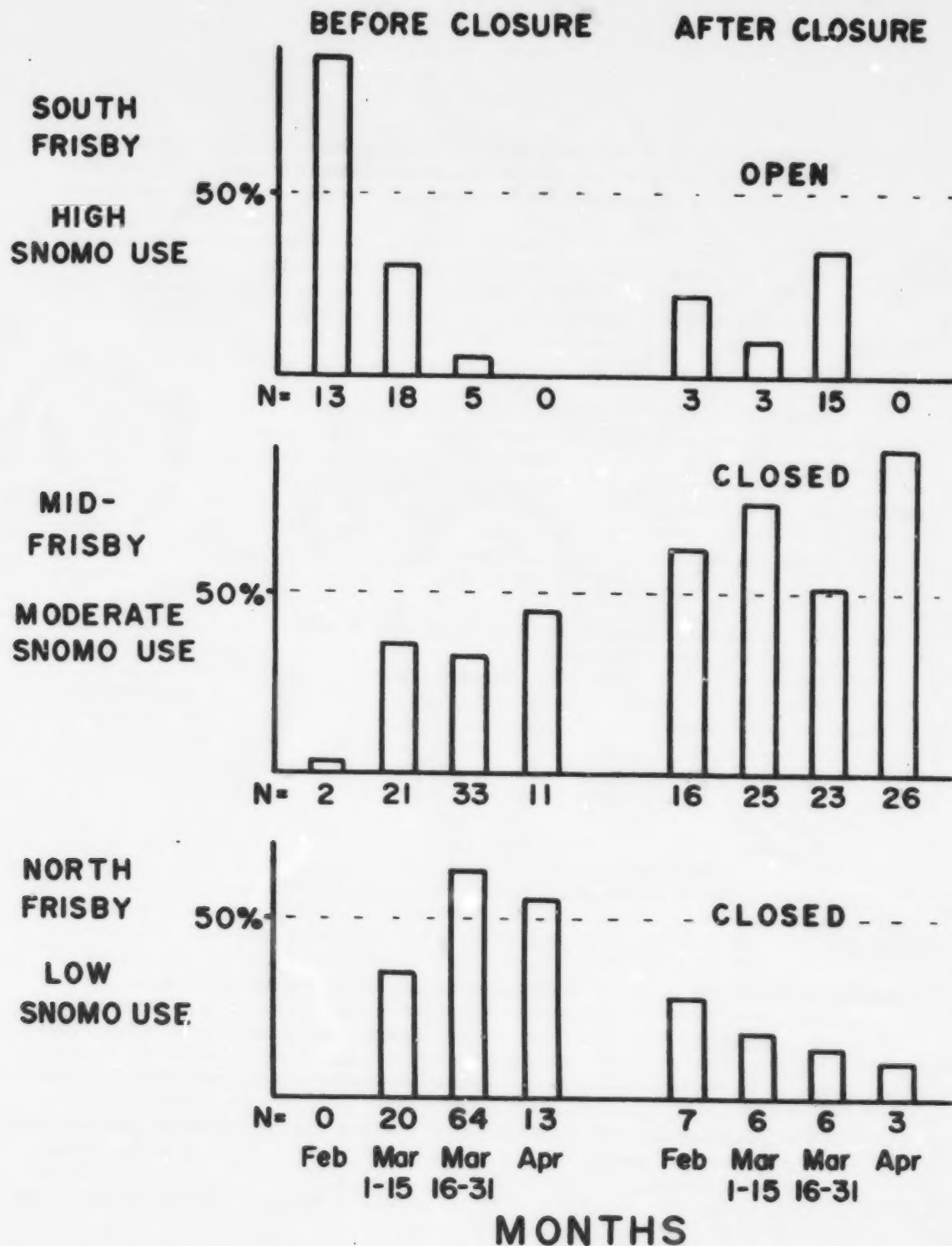


FIGURE 2. The percent distribution of caribou on Frisby Ridge before and after a voluntary snowmobile closure.

Table 2. The number of caribou seen on Frisby Ridge during aerial survey flights before and after the snowmobile closure.

	Before closure				After closure			
	Feb	Mar 1-15	Mar 16-31	Apr	Feb	Mar 1-15	Mar 16-31	Apr
No. of Flights	6	9	9	4	5	5	3	3
# caribou Seen	15	59	99	24	26	34	44	29
No. seen / Flight	2.5	6.5	11	6.0	5.2	6.8	14.7	9.7

Table 3. Snowmobile use on Frisby Ridge and weather, 1985.

Month	Snowmobile hours/day	% days with no precipitation
Jan.	8	35
Feb.	6	7
Mar. 1-15	22	73
Mar. 16-31	10	33
Apr.	20	30

Table 4. Caribou responses to experimental snowmobile disturbance.

Stimuli	N	Flight distance (m) *	Response
sight, sound	7	136 $\pm$ 281	5-walk 2-no response
sight, sound, scent	2	150 $\pm$ 50	2-ran
sound, scent	2	188 $\pm$ 12	2-ran
sound	7	286 $\pm$ 40	3-ran 3-walk 1-no resp.

* mean $\pm$ SE.

Groups of caribou were approached 18 times using either one or two snowmobiles. Seven groups ran away, eight walked away and three showed no reaction. No groups were approached closer than 100 m.

Responses were related to three basic stimuli - scent, sight and sound. Assessing each approach independently, I judged that caribou had scented me on four approaches, heard me on 17 and saw me on 9. Caribou always ran away when they scented me (Table 4). Sound and sight most often caused caribou to walk away, although three groups showed no reaction and six ran (Table 4). Three of the six groups which ran away had also scented me.

The distance that caribou allowed an approach (flight distance) varied with the type of stimulus. Flight distances were shortest ($x=139$ m) when the animals saw me (Table 4). Scent and sound elicited successively greater flight distances. Sound alone was associated with the greatest flight distances ($x=286$ m). Caribou usually moved less than 1 km immediately after disturbance ($x=0.6 \pm .2$, $N=15$) and, in all but one case, continued to use the area within 2 km of the disturbance site. The experimental disturbance never caused caribou to cross a valley or move to another ridge.

DISCUSSION

Fewer caribou used Boulder Ridge in 1984 and 1985 than from 1970 to 1974. Construction of the chalet in 1975 and increasing use of the area by the Revelstoke Snowmobile Club were believed to be the cause for the absence of caribou. All aerial sightings of caribou in 1984-85 were near the margins of the snowmobiling area and probably resulted from animals approaching Boulder Ridge from areas not accessible to snowmobiles.

Caribou numbers on Frisby Ridge have remained fairly constant although there was an insignificant trend to slightly higher use following the snowmobile closure (Table 2). The movement of caribou from south to north coincided with the increasing snowmobile use largely on the south end of the ridge from January to April. Following the closure, the reduced snowmobile use allowed more animals to remain on the central portion of the ridge. I expected more animals to use the central area because it was a larger area and was better quality habitat than the north ridge, which was mostly burned. Intensive use, which averaged 22 snowmobiling hours/day at its peak, probably caused caribou to move away from the south ridge. Bergerud (1984) stated that "...extreme and persistent harassment..." would be required to cause caribou to abandon preferred ranges. Apparently that level of disturbance has been reached on the parts of Boulder and Frisby Ridges most often used by snowmobilers.

Caribou responses to experimental snowmobile disturbance appeared to be unpredictable. Many factors affect an animal's response to human disturbances. Most researchers relate responses to learned or innate behaviour designed to avoid predators. Flight disturbances of prey species vary depending on the type of predator, season, habitat and the age, sex and physical condition of the animal (Walther 1969). In general, prey species try to avoid predators without wasting energy running away for nothing. Responses are related to the level of threat perceived by the animal, based on previous experience and their ability to locate and identify a disturbance. Sighting a snowmobiler may provide a level of security for caribou since they can assess the distance, direction and speed of the intruder and determine the potential danger (Moen *et al.* 1982, Aune 1981, Richens and Lavigne 1978). Caribou allowed the closest approaches when sighted. Caribou probably feel most secure in their ability to outrun "predators" when they can observe their movements and assess their intentions (Bergerud *et al.* 1974). Once scented, caribou withdrew quickly because, in this hunted population, they have learned to avoid people. Sound elicited greater flight distances probably because caribou did not wish to allow a potential danger to approach too closely before it could be identified. The lack of information provided by a sound stimulus promotes more wariness in caribou. The general response to the sound of a snowmobile was a slow withdrawal. In three of six cases where animals ran, I was also scented. In two of three cases where animals showed no reaction, I was also seen. In summary, sound alerted caribou and made them withdraw, scent identified me and caused them to flee. Sight elicited the least response provided I was not scented, I stayed far enough away and I did not threaten the animals by approaching them directly and rapidly. The moderate response of caribou to snowmobile sounds indicates that animals do not associate snowmobiles with bad experiences such as chasing.

The reasons that caribou avoided high use snowmobile areas relates to the presence of human scent and the mobility of snowmobiles. My experience also showed that, even when animals were known to be present, they were only sighted 50% of the time. It is possible that large groups of snowmobilers roaming through an area may unintentionally "chase" animals (Moen *et al.* 1982). Being surrounded by fast moving sound stimuli may panic caribou because they are unable to locate multiple threats while scent initiates flight. Caribou are capable of locating and avoiding a few machines, while many machines may cause panic and lead to abandonment of an area.

The success of the voluntary snowmobile closures resulted from the degree of co-operation and concern of local snowmobilers. Most users on Frisby Ridge were local residents and many of the visitors registered on the sign-in sheets were accompanied by local club members. I believe that a high degree of self policing and advertising by the Revelstoke Snowmobile Club led to the high degree of compliance observed on Frisby Ridge.

The impact of other user groups on Frisby, particularly helicopter and cross-country skiers, was not carefully monitored. Helicopters are more mobile than snowmobiles and, because caribou have been sensitized to helicopters by capture programs, helicopters have greater potential to disturb or harass them. Frisby Ridge was considered an alternative skiing area when preferred longer runs in other areas could not be reached due to poor weather. Most heli-skiing was done on the north and middle parts of Frisby Ridge. The steep slopes and avalanche paths on the west side of the ridge were the runs most commonly used. The moderately sloped ridge top was used only at five unloading sites. Helicopter skiers stayed close together so they could follow their guides to the pick-up sites in the valley bottoms. The limited time which heli-skiers spent in the favoured caribou habitat and the fact that groups stayed close together reduced their potential to disturb caribou. The use of the north and middle parts of Frisby Ridge indicated that heli-skiing was probably not a major factor influencing the caribou distribution. Under the terms of the heli-skiing licences, helicopters must fly at least 500 m above the trees and they are not permitted to approach groups of animals.

The activities of cross-country skiers were confined mainly to the area around their cabin. Ski tracks were seen only once in the area immediately south of the closure boundary. Skiers probably contribute to the caribou's avoidance of south Frisby, but the skiers' limited occurrence and range was overshadowed by the extensive snowmobile use.

CONCLUSIONS

The present levels of snowmobile use on Boulder and Frisby Ridge are incompatible with continued occupancy of the areas by caribou. The aspects of snowmobiling most disturbing to caribou are human scent and large groups of machines moving rapidly around an area. Caribou can tolerate low levels of snowmobile use and, if they are not harassed by snowmobilers, their tolerance will probably increase.

RECOMMENDATIONS

The first objective of the B.C. Ministry of Environment (MOE) should be to re-establish and maintain caribou use on the alpine ridges near Revelstoke. To accomplish this, the level of snowmobile and other human uses must be reduced during the periods that caribou are normally present. Two factors are important in determining management options:

1. Caribou may continue to use areas as close as 0.5 km from intensive human activity.
2. Caribou may become habituated to gradually increasing levels of non-harmful human activities.

I recommend that the partial closure on Frisby Ridge be continued until the level of caribou use on the south portion is equivalent to use on the mid- and northern portions. To reduce snowmobile use in the south area, I suggest that the marked access trail be re-vegetated and the guide flagging and other marks be removed. The trail packer should no longer be used on Frisby Ridge. No more than 10 snowmobilers should use the ridge on any one day and total use should not exceed 100 machine hours/month from February to April. Information signs should be erected and maintained informing users of the closure areas and instructing people not to approach caribou, to stay downwind and to avoid areas where there are caribou tracks.

I suggest maintaining Boulder Ridge as the primary snowmobiling area near Revelstoke. Access problems associated with logging road use could be easily solved through negotiations between the logging companies, Forest Service and the Revelstoke Snowmobile Club. Access to the western half of Boulder should not be enhanced so that caribou populations may be maintained adjacent to this high use area, thereby increasing the potential for habituation. It should be recognized that permitting unlimited use on Boulder Ridge represents a substantial sacrifice of prime caribou winter range and contradicts the Special Use Permit (SUP) granted in 1975 which stated that the proposed use should not interfere with caribou migrations.

Local ridges, particularly Frisby, should not be promoted as destination areas for winter recreationists until the conflict with caribou use has been resolved. Many areas exist within 50 km of Revelstoke, some not occupied by caribou, which could be developed and promoted without major resource conflicts. Any alternatives that divert snowmobilers into many areas, rather than a few, should be examined.

The Revelstoke Snowmobile Club and the Cross-Country Ski Club should, as a condition of their SUP's, be required to keep a record of users in their facilities, which would be provided to the Ministry of Environment on request. Additional snowmobile user information for Frisby Ridge should also be collected to assist in determining acceptable levels of use when the partial closure proves successful.

An impartial third party, acceptable to both the users and the MOE, should be contracted to monitor caribou use on Frisby and Boulder Ridges to ensure compliance and success. Several local pilots may be willing to perform this service at minimal cost. If caribou continue to use only the northern parts of Frisby during the next two winters, then I would recommend that the south ridge also be closed. If caribou re-establish use on the south end, snowmobile use, at an acceptable level, could again be permitted on the entire ridge.

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2.8 SOUTHERN SELKIRK CARIBOU HABITAT SELECTION

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ABSTRACT

Habitat selection of Selkirk caribou (Rangifer tarandus caribou) was studied during 1983-85. Caribou habitat selection in spring was progressive, with early preference for disturbed sites with open canopies on low elevation, south and west aspects. Preferred summer habitat was on north and east aspects at mid and upper elevations. Rut habitat appeared to be an extension of summer habitat, except lower elevations and denser overstory canopies were used. Early winter habitat consisted of low and mid elevation old growth cedar-hemlock (Thuja plicata - Tsuga heterophylla) stands on north and east aspects. Preferred late winter habitat was on south and west aspects, at high elevations, under moderate to open overstory canopies, with habitat selection becoming more generalized as the season progressed. Preferred calving areas were similar to late winter habitat and appeared to be chosen for low predator abundance. It is recommended that remaining early winter habitat on the study area be preserved, while summer and rut habitats be conservatively managed.

INTRODUCTION

The Selkirk international caribou herd has recently been the focus of much interest and concern. These animals represent the southernmost extension of caribou in North America and they have endangered species status within the U.S.. Although the mountain caribou subspecies itself is not in danger of extinction, these 25 to 30 animals are the last caribou to range within the continental United States.

Prior to significant decline, the Selkirk herd is estimated to have numbered between 100 and 200 animals (Scott 1985). Since 1950 timber harvest has cleared large areas, an all-weather highway has divided the heart of caribou habitat, fire has destroyed large portions of caribou range, and poaching has been a major source of mortality on the Selkirk herd (Johnson et al. 1977). The Selkirk caribou has been eliminated from almost all its former U.S. range and recruitment barely keeps pace with estimated mortality (Scott and Servheen 1985).

In 1982 the Idaho Department of Fish and Game began a study on this remnant herd. The objectives were to radio-collar caribou within the herd and through radio telemetry determine: 1) population status, 2) caribou habitat selection patterns, 3) reproductive biology, 4) food habitats, 5) distribution, and 6) mortality factors. Scott (1983) and Scott and Servheen (1984) provided progress reports during the study. Scott and Servheen (1985) reported on the final project results.

This study presented a number of complications because it involved two countries, two states, and numerous state and federal agencies. Because of their concern for the resource, the following agencies and people were responsible for the success of this project: B.C. Fish and Wildlife Branch, B.C. Ministry of Forests, U.S. Forest Service, Washington Department of Game, U.S. Fish and Wildlife Service, Darkwoods Forests Inc., Guy Woods, Bob Summerfield, Paul Harrington, Jim Smith, Keith Simpson, and Rick Hoar.

STUDY AREA

The study area includes the Selkirk Mountains of southeastern British Columbia, northern Idaho (Boundary and Bonner Counties), and northeastern Washington (Pend Oreille County) (Figure 1). The topography is glacially derived, with U-shaped valleys, cirque basins, and exposed rock faces common. Elevation ranges from 540 m. on the Kootenay Valley floor to 2,438 m. on Kootenay Mountain. Below 1,650 m., undisturbed sites are dominated by cedar-hemlock forests. Higher elevations (>1676 m) are primarily in the spruce-fir zone (*Picea engelmannii* - *Abies lasiocarpa*), giving way to open whitebark pine (*Pinus albicalus*), alpine larch (*Larix lyallii*), and subalpine fir stands on the high exposed ridges. Understories are quite brushy at the mid and lower elevations.

The climate of the area is under a Pacific maritime influence. Winters are relatively mild and wet compared to the mountains eastward. Most precipitation occurs as snow during October through April. Much of the study area has been logged since 1950 while fires in 1967 left large treeless blocks in Idaho's caribou habitat. Virtually every drainage has at least partial road access. Crawford and Scott (1985) provide a more detailed description of the study area and its vegetation.

METHODS

Caribou habitat selection data was collected by intensively radio-tracking six radio-collared animals (Table 1). Ground tracking consisted of approaching the caribou until they were first observed and then collecting data at hourly intervals. When the caribou appeared to move in response to the observer, hourly observations were skipped until the animals' behavior returned to normal. Instances where more than one radio-collared animal was present were treated as a single observation. Hourly observation data included group size and activity, location, weather conditions, caribou and observer track depths in snow, elevation, aspect, slope, slope position, habitat type, lichen abundance, timber stand structure, and stand species composition by basal area. Aerial radio-locations were described by topographic data collected from 1:50,000 scale topographic maps. Radio-location data was grouped into six seasonal categories based upon observed shifts in caribou habitat selection.

Habitat availability data was derived from 300 random points plotted within the combined home range of five of the six collared caribou. Preliminary topographic information (elevation, aspect, slope position) was determined for each random point plotted on 1:50,000 scale topographic maps. Radio-location data and observations of unmarked animals indicated the Selkirk caribou herd frequented a specific core area, which included most of the annual range used

TABLE 1. NUMBER OF LOCATIONS AND OBSERVATION PERIOD PER RADIO-COLLARED SELKIRK CARIBOU.

<u>ANIMAL NO.</u>	<u>AGE</u>	<u>SEX</u>	<u>PERIOD OBSERVED</u>	<u>NO. OF LOCATIONS¹</u>
48	AD	F	2/4/83 - 6/30/85	402
51	AD	F	3/17/83 - 6/22/85	462
61	IMM	M	4/28/83 - 10/7/83	113
71	AD	M	10/18/83 - 1/14/85	56
72	AD	F	5/5/83 - 5/22/84	135
76	AD	M	10/5/83 - 6/30/85	328
				<u>1,496</u>

¹ includes locations with more than one radio-collared animal present.

TABLE 2. PERCENT CARIBOU HABITAT USE IN SPRING (MAY 16 - JULY 15) 1983-85 VERSUS PERCENT HABITAT AVAILABILITY IN THE CORE USE AREA.

<u>OVERSTORY CANOPY</u>	<u>% AVAILABILITY</u>	<u>% LOCATIONS</u>
None	16.2	25.5
1-15%	25.4	19.7
16-45%	30.5	33.2
46-75%	20.3	11.1
<u>76-100%</u>	<u>7.6</u>	<u>10.6</u>
n	197	208

<u>TIMBER STAND SIZE CLASS (cm dbh)</u>	<u>% AVAILABILITY</u>	<u>% LOCATIONS</u>
Nonforest	8.8	- 1.4
53+	20.3	13.9
36-53	16.8	22.0
20-36	20.8	23.4
10-20	12.7	5.7
3-10	12.2	6.7
<u><3</u>	<u>8.6</u>	<u>+26.8</u>
n	197	209

Table 2 (continued).

NORTH AND EAST		
ASPECTS (315-134)	% AVAILABILITY	% LOCATIONS
<u>Elevation (m)</u>		
1050-1510	5.3	+12.6
1510-1810	20.3	+36.8
1810-2270	25.0	- 4.5
Subtotal	50.7	53.9
SOUTH AND WEST		
ASPECTS (135-314)		
<u>Elevation (m)</u>		
1050-1510	5.7	+19.3
1510-1810	15.7	22.4
1810-2270	28.0	- 4.5
Subtotal	49.3	46.2
n	300	223

DEGREES SLOPE	% AVAILABILITY	% LOCATIONS
0-10	19.9	+44.0
11-20	29.1	40.2
21-30	28.6	-13.9
31-40	18.4	- 1.9
41+	4.0	0.0
n	196	209

TABLE 3. PERCENT CARIBOU HABITAT USE IN SUMMER (JULY 16 - SEPTEMBER 15) AND RUT (SEPTEMBER 16 - OCTOBER 3) 1983 AND 1984 VERSUS PERCENT HABITAT AVAILABILITY IN THE CORE USE AREA.

TIMBER STAND SIZE CLASS (cm dbh)	% AVAILABILITY	% LOCATIONS	
		SUMMER	RUT
Nonforest	11.2	1.3	0.0
53+	19.7	- 5.2	+56.0
36-53	17.8	+57.1	34.7
20-36	19.7	11.7	6.7
10-20	16.4	- 3.9	- 0.0
3-10	7.9	1.3	0.0
<3	7.2	19.5	2.7
n	152	77	75

Table 3 (continued).

<u>DEGREES SLOPE</u>	<u>% AVAILABILITY</u>	<u>% LOCATIONS</u>	
		<u>SUMMER</u>	<u>RUT</u>
0-10	19.9	+53.2	+40.0
11-20	29.1	37.7	33.3
21-30	28.6	- 9.1	20.0
31-40	18.4	- 0.0	- 6.7
<u>41+</u>	<u>4.0</u>	<u>0.0</u>	<u>0.0</u>
n	196	77	75

<u>OVERSTORY CANOPY</u>	<u>% AVAILABILITY</u>	<u>% LOCATIONS</u>	
		<u>SUMMER</u>	<u>RUT</u>
None	15.1	10.4	0.0
1-15%	27.0	-11.7	- 2.7
16-45%	33.6	32.5	- 5.5
46-75%	21.1	+45.0	23.3
<u>76-100%</u>	<u>3.3</u>	<u>0.0</u>	<u>+68.5</u>
n	152	77	73

<u>NORTH AND EAST</u>		<u>% LOCATIONS</u>	
<u>ASPECTS (135-314)</u>		<u>SUMMER</u>	<u>RUT</u>
<u>Elevation (m)</u>			
1050-1510	5.3	0.0	9.8
1510-1810	20.3	+33.9	+55.9
<u>1810-2270</u>	<u>25.0</u>	<u>+41.1</u>	<u>- 2.9</u>
Subtotal	50.7	+75.0	+68.6

<u>SOUTH AND WEST</u>		<u>% LOCATIONS</u>	
<u>ASPECTS (135-314)</u>			
<u>Elevation (m)</u>			
1050-1510	5.7	0.0	0.0
1510-1810	15.7	12.5	27.5
<u>1810-2270</u>	<u>28.0</u>	<u>-12.5</u>	<u>- 3.9</u>
Subtotal	49.3	-25.0	-31.4
n	300	112	102

by radio-collared animals (Figure 2). During the summer of 1984, 200 of the random points within the core area were visited on the ground and described in the same manner as the ground radio-locations (Crawford and Scott 1985). Because mature bull No. 71 used a distinctly separate area from the other five animals, his radio-locations were not used in this habitat selection analysis.

The proportion of availability in each habitat category was compared to the proportion of radio-locations using the Bonferroni test for binomial proportions (Marcum and Loftsgaarden 1980). In the data tables, + indicates a radio-location proportion significantly ($p=.05$) larger than the proportion available; - indicates a significantly smaller proportion than that available. The absence of a sign indicates no significant difference.

RESULTS AND DISCUSSION

Spring

Spring habitat selection is characterized by caribou moving to areas where early growing green forage is available, primarily at low elevation open-canopied sites. Overstory canopies less than 45% were noted on more than 70% of the spring caribou radio-locations, while more than 25% had no overstory (Table 2). Stands of less than 3 cm. diameter breast height (dbh) were significantly preferred. Selection for low elevation south and west aspects and gentle slopes was also apparent. Spring sites are primarily areas that have been logged, including partial and clear cuts and road embankments. Open canopies at low elevation south and west aspects accelerate snow melt and allow early green-up and hence are the first sites used by caribou in the spring. As green forage becomes more abundant, the animals use a broader range of sites, including north and east aspects and higher elevations. Data collected over the entire spring tended to obscure the strong habitat selection seen early in the season. Forested areas with heavy canopies appeared to be used for lichen foraging as the animals alternated between lichens and green forage.

Summer/Rut

Because summer and rut are similar in caribou habitat selection, they are presented together. Caribou appeared to select for moist forested sites with abundant forage during these periods. Summer habitat selection was for gentle slopes at mid and upper elevations on north and east aspects (Table 3). Mature stand size classes with moderate to dense canopies were preferred. Similar to spring, summer habitat selection was progressive. The more open canopies, smaller stand sizes, and lower elevations were used earlier in the season and the larger stands with denser canopies at upper elevations were used later in the season. Summer habitat selection is apparently keyed to the availability of forage in early growth stages. Additionally, thermal cover may also be provided by summer habitat.

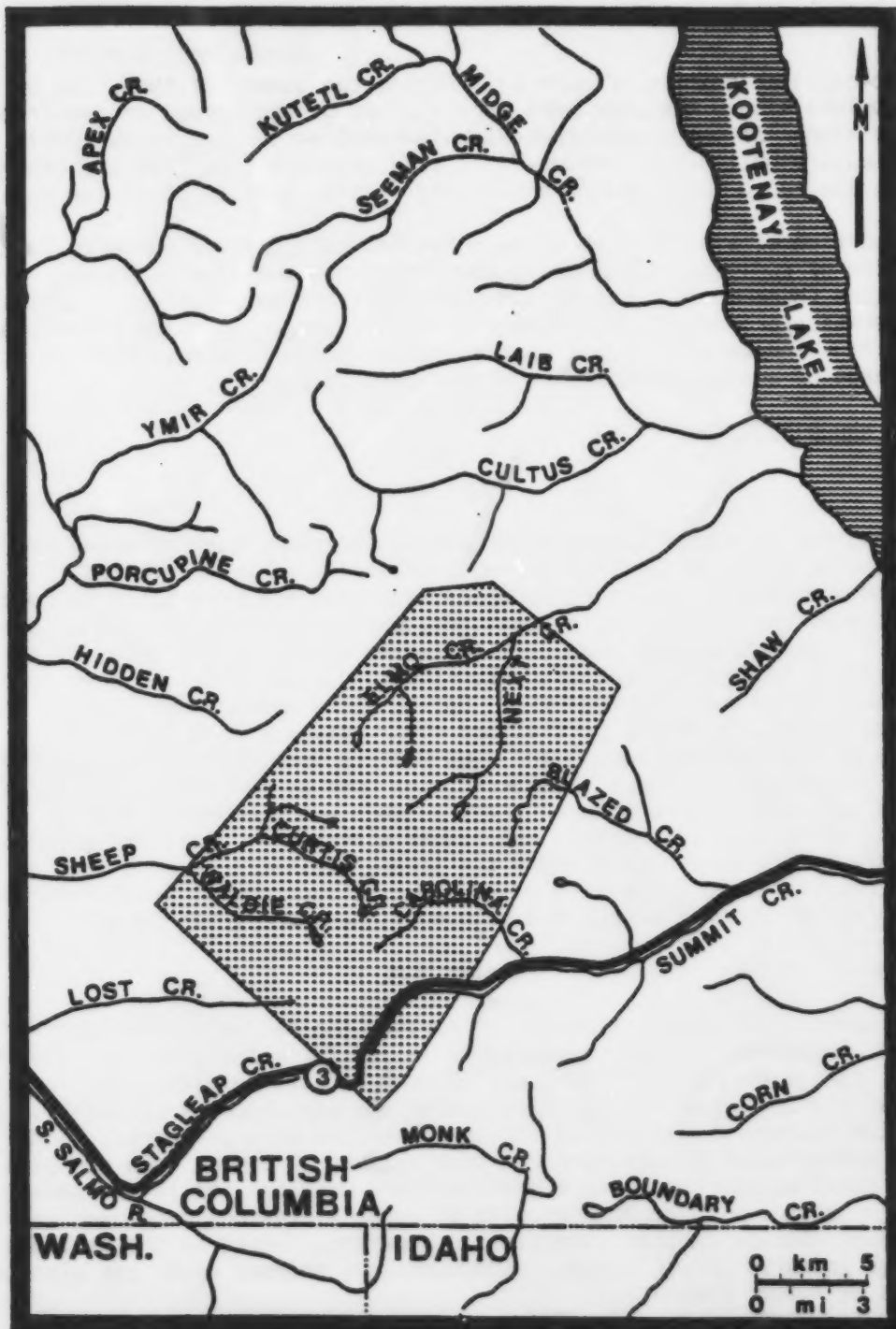


Figure 2. Caribou Core Use Area.

Rut habitat appeared to be a continuance of summer habitat selection, emphasizing densely-canopied mature timber stands at somewhat lower elevations. The lower elevations and denser canopies continue to provide green forage later in the year because these stands are on moist sites and are more protected from frost. Additionally, rut habitat may also be preferred because of the abundant lichens along the secondary stream bottoms characteristically used by caribou at this time of year. During rut the caribou are beginning to make the dietary transition from green forage to lichens.

Early Winter

Early winter is a time of limited forage and limited mobility for the Selkirk caribou. Deep soft snow buries terrestrial forages yet will not support an animal reaching to feed on arboreal lichens. This season's data is the most limited and the most ambiguous. In 1983, an apparently normal year, snowfall was gradual during the months of November and December. Nineteen eighty-four snowfall for those months was much greater than normal and apparently moved the animals to late winter habitat much earlier than normal. The 1984 data is comparable to late winter data while the 1983 data may be more representative of early winter habitat selection. In 1983, the animals selected for mid and lower elevations on north and east aspects (Table 4). Stands of large cedar and hemlock trees with dense canopies were significantly preferred in 1983. Caribou also selected for steeper slopes in early winter than during spring or summer/rut. Preliminary analysis of 1985 early winter data indicates that habitat use was similar to 1983.

Nival conditions and forage availability appear to influence early winter habitat selections by Selkirk caribou. The dense overstory canopies in old-growth cedar-hemlock stands apparently serve as a snow intercept mechanism that minimizes snow depths in the understory. This extends the time green forage is available to the caribou. Reduced snow depths in these stands may also help caribou conserve energy by easing travel costs. Preliminary interpretations of data collected in 1985 (Rominger pers. comm.) suggest that subalpine fir deadfalls may be important as a source of lichen forage. If this is the case, early winter habitats may be restricted to old growth cedar-hemlock stands along the subalpine fir-hemlock ecotone.

Late Winter/Calving

Caribou used similar seasonal habitats for late winter and calving. In late winter the snowpack will support caribou and they are able to feed on arboreal lichens found primarily in the branches of subalpine fir. During calving the parturient females move to high elevations to calve and nurse until the calf is strong and mobile. In both cases, the animals use primarily high elevation south and west aspects, with calving habitat having the steepest slopes of any seasonal caribou habitat (Table 5). Similar to spring and summer, late winter

TABLE 4. PERCENT CARIBOU HABITAT USE IN EARLY WINTER (NOVEMBER 1 - JANUARY 15) 1983 AND 1984 VERSUS PERCENT HABITAT AVAILABILITY IN THE CORE USE AREA.

NORTH AND EAST ASPECTS (315-134)		% LOCATIONS	
	% AVAILABILITY	1983	1984
<u>Elevation (m)</u>			
1050-1510	5.3	26.7	0.0
1510-1810	20.3	20.0	26.4
1810-2270	25.0	-3.3	13.9
Subtotal	50.7	50.0	40.3
SOUTH AND WEST ASPECTS (135-315)		% LOCATIONS	
	% AVAILABILITY	1983	1984
<u>Elevation (m)</u>			
1050-1510	5.7	13.3	0.0
1510-1810	15.7	30.0	11.1
1810-2270	28.0	-6.7	+48.6
Subtotal	49.3	50.0	59.7
n	300	30	72
OVERSTORY CANOPY		% LOCATIONS	
	% AVAILABILITY	1983	1984
None	16.2	0.0	5.7
1-5%	25.4	0.0	-0.0
16-45%	30.5	15.4	39.6
46-75%	20.3	30.7	+45.3
76-100%	7.6	+53.8	9.4
n	197	13	53
TIMBER STAND SIZE CLASS (cm dbh)		% LOCATIONS	
	% AVAILABILITY	1983	1984
Nonforest	8.6	0.0	0.0
53+	20.3	+69.2	+64.2
36-53	16.8	23.1	5.7
20-36	20.8	7.7	11.3
10-20	12.7	0.0	7.5
3-10	12.2	0.0	5.7
<3	8.6	0.0	5.7
n	197	13	53

Table 4 (continued).

DEGREES SLOPE	% AVAILABILITY	% LOCATIONS	
		1983	1984
0-10	19.9	23.1	23.1
11-20	29.1	23.1	44.2
21-30	28.6	15.4	30.8
31-40	18.4	38.5	-1.9
41+	4.0	0.0	0.0
n	196	13	52

HABITAT TYPE ¹	% AVAILABILITY	% LOCATIONS	
		1983	1984
Hemlock/Wet	9.6	16.7	7.2
Hemlock/Dry	12.7	+40.0	4.3
Alpine Fir/Wet	12.7	0.0	4.3
Alpine Fir/Stam ²	18.8	30.0	15.9
Alpine Fir/Rhal ³	40.1	-13.3	+68.1
Rock/Talus	6.1	0.0	0.0
n	197	30	69

¹Crawford and Scott 1986

²Streptopus amplexifolius

³Rhododendron albiflorum

TABLE 5. PERCENT CARIBOU HABITAT USE IN LATE WINTER (JANUARY 16 - MAY 15) AND CALVING¹ (JUNE 2 - JULY 15) 1983-85 VERSUS PERCENT HABITAT AVAILABILITY IN THE CORE USE AREA.

OVERSTORY CANOPY	% AVAILABILITY	% LOCATIONS	
		CALVING	LATE WINTER
None	15.1	0.0	-3.2
1-15%	27.0	15.0	-13.4
15-45%	33.6	+56.7	25.3
46-75%	21.1	28.3	+32.8
76-100%	3.3	0.0	+25.3
n	152	60	253

¹ Calving data is derived only from parturient females.

Table 5 (continued).

<u>DEGREES SLOPE</u>	<u>% AVAILABILITY</u>	<u>% LOCATIONS</u>	
		<u>CALVING</u>	<u>LATE WINTER</u>
0-10	19.9	18.3	+37.0
11-20	29.1	36.7	37.8
21-30	28.6	25.0	20.5
31-40	18.4	20.0	-4.7
41+	4.0	0.0	0.0
n	196	60	254

<u>NORTH AND EAST ASPECTS (315-134)</u>		<u>% LOCATIONS</u>	
<u>Elevation (m)</u>		<u>CALVING</u>	<u>LATE WINTER</u>
<u>1050-1510</u>		5.3	2.2
<u>1510-1810</u>		20.3	22.4
<u>1810-2270</u>		25.0	21.1
Subtotal	50.7	36.7	45.7

<u>SOUTH AND WEST ASPECTS (135-314)</u>		<u>% LOCATIONS</u>	
<u>Elevation (m)</u>		<u>CALVING</u>	<u>LATE WINTER</u>
<u>1050-1510</u>		5.7	4.7
<u>1510-1810</u>		15.7	-7.1
<u>1810-2270</u>		28.0	+42.5
Subtotal	49.3	63.3	54.3
n	300	68	322

habitat selection is progressive. Strong selection for open canopied stands on south and west aspects occurs early in late winter. These areas are most subject to the wind and sun action which firms the snowpack, allowing for easier locomotion. As the winter progresses and the snow begins to firm up in other areas, the animals appear less selective and use lower elevations, denser canopies, and different aspects. Data collection throughout the entire winter tends to obscure this early habitat selection.

Calving habitat selection appears to be for areas low in predator (primarily bears) abundance. In June and July, when calves are most vulnerable, bears concentrate at lower elevations to forage. Female caribou with calves apparently choose to remain at high elevations, sacrificing forage quality for increased calf security.

RECOMMENDATIONS

Early winter habitat appears to be the most critical management priority. These old growth stands are difficult to produce and are in high demand for timber harvest. On the study area, the availability of these stands has been greatly reduced. The remaining stands should be maintained for the present. Further study of early winter habitat is needed to better identify the characteristics and function of these stands in caribou ecology. The other seasonal habitats are both more widely available and more compatible with timber management objectives. Spring habitat is currently abundant on the study area. However, if needed, timber harvest can be used to improve and/or create spring habitat. Late winter and calving habitats are primarily non-commercial stands, which in some cases could be improved by partial overstory removal but are generally uneconomical to harvest. Late summer and rut habitats are primarily mature spruce/fir stands. On the study area these areas have also been heavily logged. We recommend that the remaining areas be conservatively managed as critical caribou habitat. In areas less disturbed, we feel that good silvicultural practices, primarily uneven-aged management, can have a minimal impact on summer habitats. We recommend that rut habitats, primarily secondary stream bottoms, be left undisturbed.

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2.9 CARIBOU HABITAT MAPPING IN BRITISH COLUMBIA: EVOLUTION TOWARDS A STANDARD APPROACH

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INTRODUCTION

There are three main themes in this paper. The first briefly outlines the evolution of habitat mapping within British Columbia by Ministry of Environment personnel. A multidisciplinary team approach has been developed and subsequently maintained within the biophysical mapping program of the Ministry. A single integrated habitat map is now being produced rather than several single discipline maps.

Secondly, a habitat mapping project carried out for delineating and determining seasonal habitat use by caribou for the Level Mountain and Horseranch Ranges is briefly summarized. The problems, common to all wildlife - habitat studies, of quantifying habitat use and animal observations are discussed.

The last theme summarizes the experiences gained from previous habitat mapping projects and recommends that a standard approach to mapping habitats, recording animal observations, and assigning wildlife values be taken.

I. EVOLUTION OF HABITAT MAPPING IN BRITISH COLUMBIA

The first attempt at mapping habitats in British Columbia was under the Canada Land Inventory (C.L.I.) program during the 1960's and early 1970's (Blower 1973). Wildlife and waterfowl biologists used a direct interpretation approach drawing map units based on knowledge of animal habitat requirements. Habitat parameters such as: climate boundaries, which were drawn to approximate snow depth; and landform features, which depicted escape terrain, were combined to create habitat units that were given a capability rating. These 1:250 000, scale, published C.L.I. ungulate capability maps are available from Maps B.C. The emphasis of this program was to produce capability maps and some habitat factors (limitations) were shown on these maps along with ratings (from 1 to 7) for each map unit.

The C.L.I. program was not designed to systematically describe habitats, species habitat requirements or to produce habitat maps. Very little of the rationale on which the units were rated was documented and available for future use. In summary, with this direct interpretation approach the biologists rated the habitat without describing the habitat or what parameters were considered important for the separation of each unit or how parameters should be used in making ratings.

With the completion of the initial C.L.I. maps the program emphasis was changed to focus more on detailed (1:50 000 scale) mapping. The direct interpretation approach for forestry, agriculture and wildlife was replaced by a base map which would contain all the parameters necessary to make interpretations and show areas with similar biological productivity. The landscape was segregated into distinct units based on soils and/or geomorphological features initially interpreted from aerial photographs and later checked on the ground. Wildlife biologists were able to use these soil maps together with information on vegetation and species habitat requirements

as a surrogate for habitat maps and units to which wildlife capability ratings could be assigned.

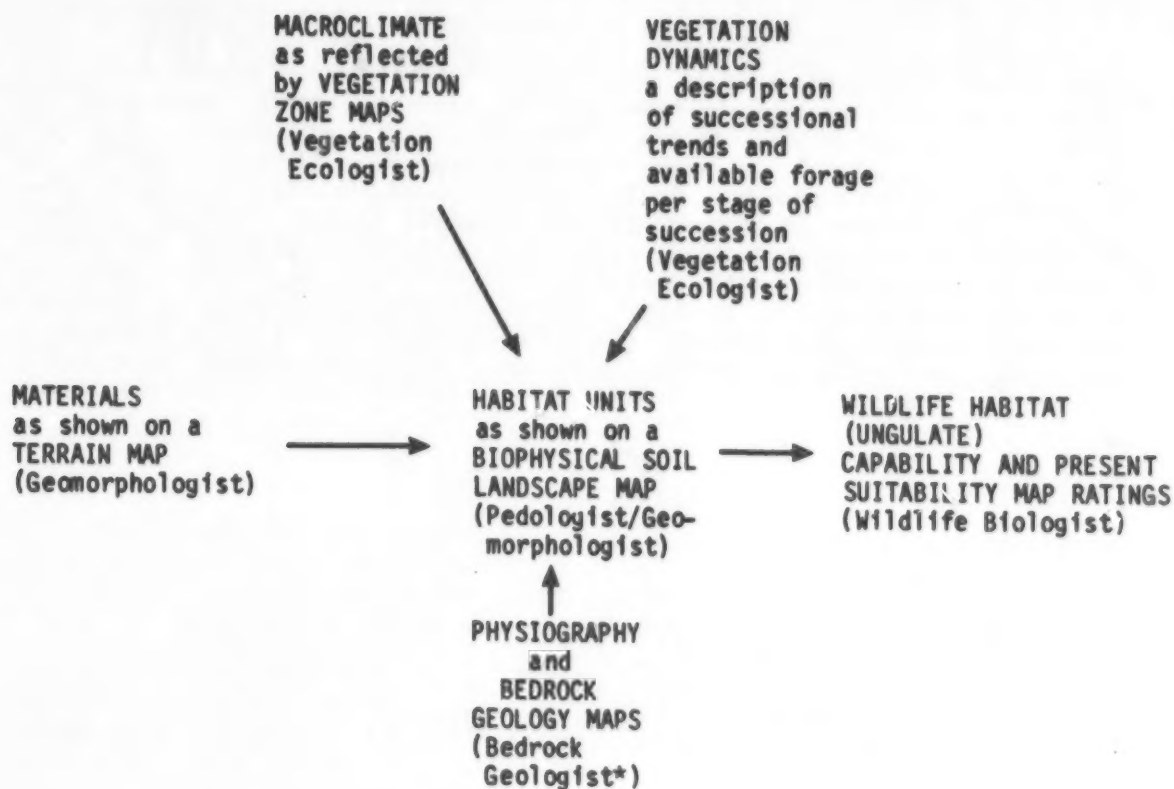
Historically, soil surveys first occurred in agricultural areas. The major purpose of these first surveys were to identify and map the main soil types so that agricultural development and practices could be planned according to the nature of the soils (McKeague et al. 1978). It was not long before other applications of soil survey information was recognized such as location of land suitable for specific uses, such as planning of roads, urban development and determining the present habitat suitability of a soil unit depending on the present successional stage. The first major soil survey in B.C. investigated the ills of the tree fruit industry in the Okanagan Valley. Surveys continued into the Similkameen and Lower Fraser Valleys. A preliminary soil survey, for forestry purposes, was done at Campbell River to assist the Forest Service in its tree planting project. From this early beginning, soil surveys expanded to many parts of the province with its major emphasis on agricultural lands. With the advent of the C.L.I. program, soil surveys were used to assist in the capability mapping. This was the beginning of soil mapping for all lands in the province.

As the emphasis for mapping soils changed, a multidisciplinary biophysical team approach was taken, as outlined by Walmsley (1976). This biophysical approach can be viewed "as a building block process that encourages the synthesis of physical and biological data (landforms, materials, soils, climate, vegetation and organisms) to form ecologically (biophysically) significant units", (Demarchi 1982). The multidisciplinary team consisted of a geomorphologist, a pedologist and a vegetation ecologist. Each member of the team was responsible for a map product. For example, a terrain map, soils map, and vegetation zone, subzone and landscape map were all separately produced. The wildlife biologists could extract habitat information from these base maps and rate land for ungulate capability. But as yet, there was still no single habitat map and, more importantly, there was still no record of the species habitat requirements, nor was there a system to show how habitat factors were weighted in order to determine the specific capability ratings (see Demarchi et al. 1983).

The multidisciplinary, multi-product approach was changed in 1984 and now the inventory program was organized along functional lines so that each Provincial Ministry would carry out work that multidisciplinary team had previously done: ie., agriculture would continue with soil surveys, for agriculture only; municipal affairs with urban suitability studies; and wildlife with habitat mapping and wildlife capability ratings.

Currently, the multidisciplinary biophysical method has been maintained in order to do habitat mapping, however, a single habitat map base is now being produced solely for the convenience of the wildlife and habitat protection biologists. Furthermore, this habitat map is shaped largely by the biologist's understanding of wildlife species habitat requirements. Figure 1 shows how the multi-disciplinary team functions to produce a habitat map. Figure 2 details the breakdown of responsibilities in a mapping project.

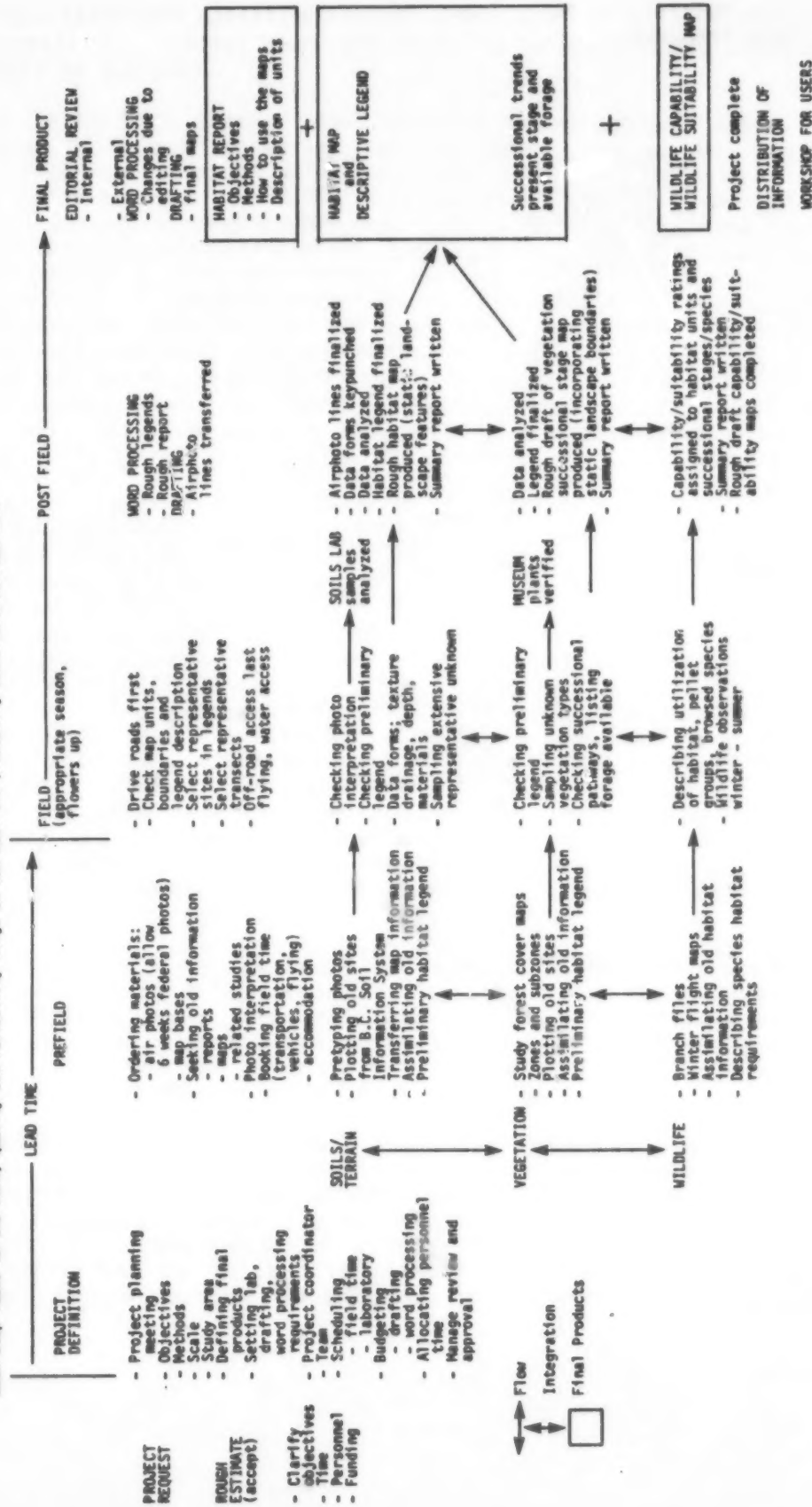
Figure 1. The Multidisciplinary Team: Responsibilities, Interrelationships and Products¹.



* not on team, maps and reports usually available

Figure 2. BIOPHYSICAL HABITAT MAPPING FLOW CHART (a multi-disciplinary team approach)

Each step leads to the next, quality and reliability hinge on how well the preceding tasks were carried out.



II. A CASE STUDY IN HABITAT MAPPING: SEASONAL HABITAT USE BY CARIBOU ON THE LEVEL MOUNTAIN AND HORSERANCH RANGES

The following discussion has been summarized from the final report and maps produced for this area (see Fenger et al. in prep.).

Two caribou ranges in northern British Columbia were described in terms of vegetation, general terrain, soil characteristics, geology and climate, Figure 3. Vegetation and general terrain and soil characteristics important to caribou (habitat) were mapped and described at a scale of 1:100000 for each range (Clement and Fenger 1981a, 1981b). In terms of the evolution of habitat mapping, these maps were the first maps to combine the physical (soils and terrain) information with the biological (vegetation) information to show habitat units. Caribou sightings from caribou census flights (Elliott et al. 1984, Page 1985) were related to various habitat map units. A separate caribou habitat use map (Page and Eastman 1984a, 1984b) identified areas most heavily used during the rut, calving, post-calving, summer and winter periods.

METHODS

Habitat mapping was carried out by an interdisciplinary team consisting of a pedologist and a vegetation ecologist. The two study areas were mapped on 1:60 000 and 1:72 000 scale, black and white aerial photographs. Both a vegetation description and a general terrain description was completed for each map unit (polygon). (Together, the physical and biological characteristics were considered to be a description of habitat.) This habitat information was presented on the Wildlife Habitat Map by a complex connotative map symbol, i.e., DE-SW/M2 which describes a map unit with Dwarf willow and Sedge willow vegetation types present on a relatively uniform, deep, well-drained morainal landscape. A more detailed description can be found on the Wildlife Habitat Map Legends (Clements and Fenger 1981a, b, c, d and e).

Caribou census surveys were flown without prior knowledge that locations would be subsequently related to habitat units; consequently, it was not always possible to link a sighting to a specific habitat. The dates of the various caribou surveys flown on Level Mountain are shown in Table 1.

A description of caribou seasonal use categories was based on seasonal activity patterns, dividing the year into winter, calving, post-calving, summer/fall and rut. Each category is defined on the Seasonal Habitat Use by Caribou Legend, one of which is shown in Table 2.

The seasonal use of the various habitat units (Table 3) was obtained by overlaying maps with animal observation from the sixteen flights onto the habitat map. This overlay process was not without problems, as some caribou observations on the original flight maps were recorded with a circle, in which case, the center of the circle was used as the location. Additional information recorded on the flight maps, such as elevation, helped to place sightings more precisely.

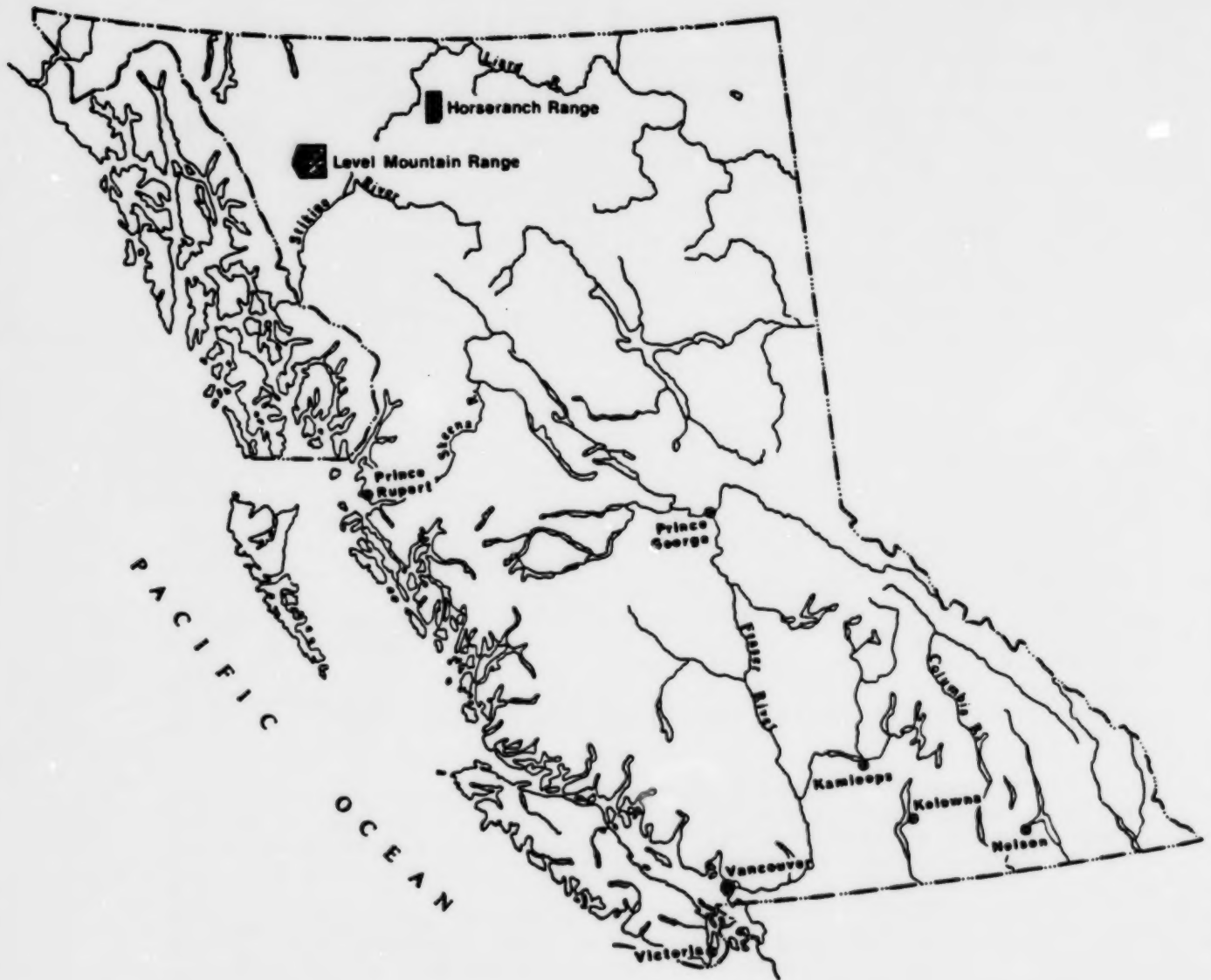


Figure 3. Location of Level Mountain and Horseranch Range Study Areas

Table 1. Survey flights for the Level Mountain Range.

Flight No.	Date	No. animals	No. groups	Average group size
RUT				
1	Oct. 06/78	33	3	11
2	Oct. 11/78	282	13	22
3	Oct. 21/79	180	6	30
4	Sept. 27/80	165	6	28
5	Oct. 21/81	75	1	75
6	Oct. 13/81	108	3	36

Rut Total		843	32	26.34
WINTER				
7	Jan. 13/79	27	2	13.5
CALVING				
8	June 18/78	243	11	22
9	June 02/80	36	11	3
10	June 04/80	60	23	3
11	June 05/80	78	27	5
12	June 07/80	100	21	5
13	June 08/80	27	7	4
14	June 10/80	113	30	4
15	June 09/80	93	31	3
16	June 10/81	3	3	1

Calving Total		753	164	4.59

Total		1,623	198	8.2

Table 2. Description of Caribou Use Map Units.

Map Unit Symbol Name	Typical Period of Use	Postulated Habitat Use Behavior	General Description of Habitat Used		Comments
			Elevation (m)	Vegetation/Terrain (See Habitat Map) Box 4	
W Winter	mid-Nov. to mid-April	During this season, caribou attempt to find forage, minimize energy expenditures, and escape predation. Forests in these units modify snow so that it tends to be softer, shallower and less crusted than in the open. This enhances access to winter forages such as arboreal and terrestrial lichens, and sedges. When snow becomes deep, heavy or well crusted, caribou shift to windswept areas that occur mostly at higher elevations. These areas offer some forage and a greater opportunity to escape predation than less favourable snow conditions in the timber.	<1210 m (4000 ft)	Located mostly to the east and north parts of the map area, winter ranges are usually mature (>60 years) white spruce (WS3) and lodgepole pine stands (LP3) growing on moraines channelled by glacial meltwater and, to a minor extent, on kame deposits (M3 G1)	Much of the column titled Postulated Habitat Use Behavior has been extrapolated from the more numerous and detailed observations of caribou for the Level Mountain Range. It is postulated that the seasonal patterns and habitat types caribou use there are similar for the Horseranch Range caribou.
C Calving	mid-April to mid-June	In spring, pregnant cows move to calving areas that minimize risks from predation, either by using escape terrain with good visibility such as steep, isolated rock outcrops situated higher than the usual areas travelled by terrestrial predators, or by dispersing widely over shrubby vegetation that affords concealment and a lowered probability of detection.	1210-1670m >1820 m (4000- 5000 ft. and >6000 ft.)	Alpine tundra in cinquefoil-rock, dwarf willow, and cassiope-fescue plant communities (CR, DW, CF) found on moderately to steeply sloping bedrock outcrops and associated rubbly, colluvial aprons; on both east and west sides of the Range (C4, R2).	Non-pregnant caribou occur in areas from 1200 to 1670 m (4000-5500 ft.) between the winter ranges and post-calving aggregation sites, the rate and extent of movement is strongly influenced by snow melt patterns; terrain is mostly shallow to deep moraine with patterned ground common.
S Summer/fall	mid-July to late Sept.	After post-calving, caribou disperse in response to insect harassment, by seeking out snow patches and exposed microsites where insect density is reduced; and a need to forage by seeking out nutrient-rich sites with minimal interferences or competition from conspecifics: vulnerability of calves to predation has diminished.	>1515 m (5000 ft) to crest of ridges	Alpine tundra communities mostly willow-moss and cinquefoil-rock (WM, CF) on the east side of the main spine of the range, landscape includes deep and shallow moraine, rubbly colluvial sites and steep rock outcrops (M6, C4, R1), rubbly colluvial and steep rock outcrops with their associated rubbly aprons.	
R Rut	late Sept. to mid-Oct.	By late September, most caribou aggregate for the rut on gently sloping or rolling terrain with low vegetation, where herd members are easily visible to each other.		Willow-moss communities (WM) in the alpine tundra mostly over gently to moderately sloping morainal deposits (M6), usually deep.	

Table 3. Summary of Caribou Observations for all Surveys for Habitat Units on the Level Mountain Range.*

Habitat units	Season Symbols**	RUT		WINTER		CALVING		TOTAL
		6 survey flights		1 survey flight		9 survey flights		16 survey flights
		observ. (caribou)	% caribou	observ. (caribou)	% caribou	observ. (caribou)	% caribou	observations (caribou) /all seasons
1. AB-BB/M4		-	-	-	-	3 (7)	1%	3 (7)
2. AF-SW/M1		-	-	1 (3)	11%	-	-	1 (3)
3. BB/C3		-	-	-	-	1 (2)	<1%	1 (2)
4. BB/M7		-	-	-	-	3 (12)	2%	3 (12)
5. BB-FE/M5		2 (16)	2%	-	-	11 (22)	3%	13 (38)
6. BB-SW/M5		2 (26)	3%	-	-	6 (17)	3%	8 (43)
7. BB-AB/G		-	-	-	-	1 (1)	<1%	1 (1)
8. BB-AB/M5		-	-	-	-	3 (6)	1%	3 (6)
9. BB-DW/C4		-	-	-	-	1 (2)	<1%	1 (2)
10. BB-FE/M5 or M7		-	-	-	-	8 (15)	2%	8 (15)
11. BF-SW/M7		-	-	-	-	5 (19)	3%	5 (19)
12. BW-SW/M2		-	-	1 (24)	89%	-	-	1 (24)
13. DW-RS/R5		-	-	-	-	2 (4)	<1%	2 (4)
14. FE/M5		1 (42)	5%	-	-	1 (3)	<1%	2 (45)
15. FE/R2		-	-	-	-	1 (6)	1%	1 (6)
16. FE-SW/M5		5 (308)	37%	-	-	3 (83)	11%	8 (391)
17. FE-BF/M5		-	-	-	-	2 (4)	1%	2 (4)
18. FE-DW/M7		6 (169)	20%	-	-	3 (15)	2%	9 (184)
19. FE-BF/M5		1 (3)	<1%	-	-	-	-	1 (3)
20. FE-BB/M5 or M7		2 (54)	7%	-	-	1 (2)	<1%	3 (56)
21. FE-BB-M5		1 (6)	1%	-	-	1 (1)	<1%	2 (7)
22. KO-SW/M5		2 (13)	2%	-	-	4 (8)	1%	6 (21)
23. KO-SW/R2		-	-	-	-	5 (19)	3%	5 (19)
24. KO-RS/M3		1 (12)	2%	-	-	13 (64)	8%	14 (76)
25. KO-RS/R2		7 (185)	24%	-	-	7 (28)	4%	14 (213)
26. KO-BF/M5		1 (2)	-	-	-	14 (157)	21%	15 (159)
27. LP1/BE/M1		-	-	-	-	2 (4)	<1%	2 (4)
28. RB/C4		-	-	-	-	1 (6)	<1%	1 (6)
29. RB/R1		-	-	-	-	2 (12)	2%	2 (12)
30. RS/C4		-	-	-	-	1 (6)	1%	1 (6)
31. RS/R5		-	-	-	-	1 (9)	1%	1 (9)
32. RS-BF/C4		-	-	-	-	4 (9)	1%	4 (9)
33. RS-RB/C4		-	-	-	-	7 (30)	4%	7 (30)
34. RS-DW/R1		-	-	-	-	1 (2)	<1%	1 (2)
35. RS-RB/C3-C4		-	-	-	-	20 (99)	13%	20 (99)
36. RS-RB/G2		-	-	-	-	3 (7)	1%	3 (7)
37. RS-RB/R1		-	-	-	-	16 (7)	9%	16 (67)
38. RS-BB/M5		-	-	-	-	1 (4)	<1%	1 (4)
39. RS-RB/C2		-	-	-	-	2 (4)	<1%	2 (4)
40. SW/F1		-	-	-	-	2 (4)	<1%	2 (4)
41. W1-SW/M5		1 (7)	1%	-	-	1 (1)	<1%	1 (1)
42. WL-AB/M5		-	-	-	-	1 (1)	<1%	1 (1)
TOTALS		32 (843)	100%	2 (27)	100%	169 (753)	100%	198 (1,623)
No. of Units Used		13		2		39		42

* The table assumes that all habitat units were searched equally each survey flight. The first number represents the number of times that caribou were counted in the habitat unit, the second number is the number of animals counted, for example unit 35 had 99 caribou seen in 20 different locations on 9 flights.

** Habitat unit symbols are defined on the Habitat Map Legend (Clement and Fenger 1981 b, d and e).

The error in observation location was estimated approximately by recording the number of other map units within a 300 m radius of the point chosen to represent the location. If the number of habitat map units into which the caribou could be placed was greater than three, the observation was not used. If two polygons occurred within the 300 m circle, the location was assigned to the unit closest to the center of the circle.

Despite the problems of determining which habitat type was being used some general trends were apparent.

Two calving habitats were identified on Level Mountain, one with bog birch-fescue dominated vegetation on gently undulating terrain located around the perimeter of the plateau, and the second at high elevations in sedge-dominated vegetation on rubbly, steep slopes, on the central peaks. On the Horseranch Range, only the more rugged area in which the cinquefoil-dwarf willow-cassiope-fescue dominated vegetation associated with the central axis was identified as calving habitat.

Post-calving aggregation sites appeared to be a restricted habitat-type, and could possibly be a limiting habitat factor for the caribou populations. Immediately after leaving the calving sites, the Level Mountain caribou selected a single, small habitat unit of fescue and bog birch-fescue on shallow moraine and remained within an area of less than 100 ha for a two to three week period at a critical time for calf survival (Page 1985). Similar restricted areas were available in only four locations within the Horseranch Range.

Summer range habitat on both study areas were more extensive than either calving or post-calving habitat. On both the Horseranch Range and Level Mountain areas, summer range overlapped the areas used for rutting habitat but not calving habitat.

Areas suitable for rutting were considered to be those that provided caribou with a relatively unobstructed line of sight to facilitate group interactions. Such open habitat, composed of kobresia-fescue, sedge, sedge-willow and dwarf willow dominated vegetation on gently undulating areas, was three times as abundant on Level Mountain as on the Horseranch Ranch. Only the eastern flank of the Horseranch Range, with gently undulating, deep moraines that were vegetated by willow-moss, mountain avens and cassiope-fescue, provided suitable rutting habitat.

Winter habitat appears widely distributed within the boreal forests surrounding both study areas. Mature stands of white spruce and lodgepole pine capable of producing lichen, appear to be favoured. Winter habitat does not appear to be limiting in extent, although accessibility and availability doubtlessly varies with snow cover.

III. WHICH WAY FROM HERE?: HABITAT MAPPING AND QUANTIFYING HABITAT USE

The challenge of the future is to better quantify animal use of habitat.

The identification of wildlife habitat use is the upper most layer of the "biophysical layer cake". It is the most difficult to reliably predict as it hinges on the reliability of the preceeding steps, coupled with the often incomplete or poor understanding of habitat use, habitat requirements and low levels of qualified habitat use per species per season.

The key to a better understanding of the use of habitat by caribou and other ungulates will only be achieved when habitat information and animal information are considered together in any data gathering program.

The following are several ways of improving the process:

1. Habitat mapping and classification work should preceed census work. A habitat map provides a standard set of units and definitions against which animal observations can be analysed. However, this approach assumes that all the important habitat characteristics are known in advance. Therefore, some previously unidentified, yet important habitat may have to be added to the map after the census work. A standard approach to mapping habitat is shown in Figure 4. This logical step by step approach should be taken for any habitat mapping project and would have benefitted the Level Mountain and Horseranch Range study by identifying caribou habitat requirements prior to habitat mapping. Since habitat maps are produced only at small scales in some restricted areas, there is a temptation to substitute forest cover maps, readily available at large scales throughout the province, as habitat maps. Forest cover maps are not habitat maps as they do not show available forage, understory species, and they do not describe site characteristics which determine successional trends. Only at a very general level can forest cover types be used to quantify animal use of habitat.
2. All census work should contain observations on habitat in order to develop better understanding of habitat use by each species. This recommendation requires observers to be able to identify specific habitat types when collecting census information. If the habitat and wildlife use of habitat is to be quantified and analysed, then standard habitat types should be agree upon prior to census work. This is especially true if comparisons are to be made using observations recorded by different observers on different flights. The number of classes of habitat recognized determines the level to which habitat use can be described, and quantified after the survey, for example if only Alpine and Non-Alpine habitat types are consistently recorded then future analysis will be limited to only these two classes.
3. Locations of animal sightings on a map base using a system such as that outlined for winter flying (Demarchi et al. 1983) is the minimum standard for recording wildlife observations (see Table 4). Using this system a map is created for each census flight with a standard set of symbols for animals observed, track abundance, snow depth observations along the flight path followed. Although this map represents only one point in time, it does become a document for future reference, as it is a part of a standardized data base showing geographic distribution. The

Figure 4. STEPS USED FOR MAPPING BIOPHYSICAL HABITAT. (After Fenger 1985.)

1. IDENTIFY WILDLIFE HABITAT REQUIREMENTS

2. MAKE A HABITAT MAP LEGEND

Using biophysical land classification steps, identify:

A STATIC
LANDSCAPE
CHARACTER-
ISTICS

1. Wildlife Ecosystems
(provincial framework)
2. Vegetation Zones and Subzones
(macroclimate, snowdepth)
3. Surficial Materials
(broad groups affecting vegetation growth)
4. Landscape Features
(aspect, slope, floodplains, avalanche tracks)

+

B DYNAMIC
VEGETATION
CHARACTER-
ISTICS

5. Successional Stages
(recent disturbance, age of stand)

= C

HABITAT MAP UNITS WITH PREDICTIVE POTENTIAL

6. Wildlife ratings per map unit per successional stage
(high, moderate, low and nil).

3. MAKE A HABITAT MAP (BOUNDARIES)

Using biophysical land stratification steps, identify:

"HARD
BOUNDARIES"*

1. Slope and Aspect
(from topographic maps)
2. Surficial Materials and Some Landscape Features
(from soil, terrain and topographic maps and
landsat images)

"SOFT
BOUNDARIES"*

3. Biogeoclimate Zones and Subzone
(macroclimate based on vegetation distribution)
4. Wildlife Ecosystems
(physiography and regional climate)

* Hard map unit boundaries can be found on the ground whereas soft boundaries are more conceptual and represent environmental transitions.

Table 4. Aerial Survey Legend. (After Demarchi, et. al. 1983)

1. Introduction

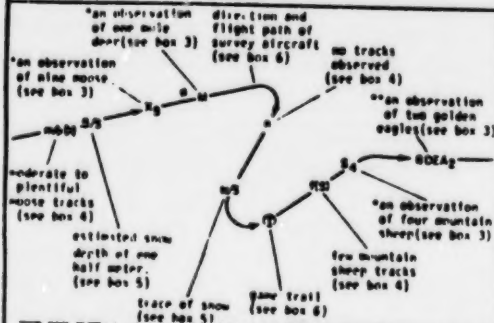
These aerial surveys are generally conducted to determine the distribution and relative abundance of wild ungulates. This legend is designed to account for the rapid observation and recording of animals, sign, and snow conditions. In addition this legend provides a standard format for recording the area surveyed and flight route taken. While the intended purpose of this data recording format is ungulate surveys, it is also useful for recording any animal observations in map form.

Advantages of recording wildlife data in map form are: to precisely locate the observations within the landscape; to indicate animal distribution; to display the proportion of an area surveyed relative to the total environment; and to be able to compare the transects of any given surveys with those from other surveys conducted over the same map area.

Field observations additional to those covered by this legend are recorded in survey transcripts or reports. For example, a survey transcript details information such as time of survey, weather and observation conditions along a transect and time since last snowfall. Other data not readily stored in map form and best recorded in reports include age and sex classification, habitat description, comments on animal behaviour, and survey intensity.

When a transcript and/or report accompanies a map it will be noted on this legend (see box 7 Survey Details).

2. Example of Map Symbols



* The number of individuals per species sighting is indicated by a subscript numeral following the species code, except in the case of a single animal which is indicated by the species code itself.

** Other species not listed in the legend are indicated by a four letter code. Refer to the publication noted in box 3 for the complete list.

3. Species

Ungulate species observed during the survey are recorded on the map using the following symbols:

UNGULATE SPECIES	SYMBOL
Mule Deer	M
Black-tailed Deer	B
White-tailed Deer	W
Moose	X
Caribou	C
Mountain Sheep (includes both species)	S
Elk	E
Mountain Goat	G

Other large mammals commonly observed during surveys are recorded using the following symbols:

SPECIES	SYMBOL
Wolf	WO
Coyote	CO
Red Fox	FO
Black Bear	BB
Grizzly Bear	GB

Observations of other species will be recorded on the map using a four letter code developed for all vertebrate species. For example, a wintering would be coded as WOLV, a bald eagle BAE, etc. For a complete listing of codes refer to Appendix 1 of the publication 'Data Entry Procedures for Ecopassion Description Form: Wildlife' by Pendergast et al., Terrestrial Studies Branch, Ministry of Environment, Victoria, 1982.

4. Track Abundance

Track abundance is a subjective estimate of track accumulation in snow which provides a useful indication of distribution at the time of the survey.

TRACK ABUNDANCE	SYMBOL
All Tracks	a
All to Few Tracks	a/f
Few Tracks	f
Few to Moderate Tracks	f/m
Moderate Tracks	m
Moderate to Plentiful Tracks	m/p
Plentiful Tracks	p

The species responsible for tracks will be indicated by the species code in brackets following the track abundance symbol. For example:

- a few mountain sheep tracks are recorded as f(S)

- moderate to plentiful moose and caribou tracks are recorded as m/p(X,C)

When the species responsible for tracks can not be determined, the track abundance symbol is recorded by itself. For example:

- moderate tracks by an undetermined species is recorded as m

When tracks are partially snow covered, melted out, or otherwise obscured and old looking, the track abundance symbol and species code are followed by the term "OLD". For example:

- moderate moose tracks covered by snow is recorded as m (X) OLD

In some surveys the number of animals responsible for a series of tracks is estimated. This is indicated by the symbol "n" followed in brackets by the species code and estimated number. For example:

- the tracks of a herd of 6 caribou is recorded as n(C6)

- the tracks of a pack of 9 wolves is recorded as n(W9)

Table 4. (continued...)

6. Snow Depth	
Snow depths are routinely estimated from the air into the following categories.	
ESTIMATED SNOW DEPTH	SYMBOL
No Snow	n/s
Trace of Snow	tr/s
0.25 metres of snow	.25/s
0.5 metres of snow	.5/s
0.75 metres of snow	.75/s
1 metre of snow	1/s
1.5 metres of snow	1.5/s
over 1.5 metres of snow	>1.5/s
Actual snow depth measurements are indicated by a boxed snow depth symbol. For example:	
A measurement of 67 cm is recorded as	67/s

6. Miscellaneous Symbols	
Symbols which are used to indicate other observations and particulars relative to the survey are as follows:	
Survey flight path and direction	SYMBOL →
Beginning of survey	→
Termination of survey	→
Transect number	12
Aircraft landing site	+
Off map notation number (this symbol indicates comments pertaining to a specific site on the map which have been recorded in a transcript or report)	21
Mineral lick	L
*Game trails (other than in snow)	T
*Dead animal	K
*Shed antler	A
*Den site	D
*Nest site	N
*If determinable, the species associated with this symbol may be indicated in brackets following the symbol. For example:	
A shed caribou antler is recorded as	A(C)
A dead mouse is recorded as	K(X)

7. Survey Details	
Survey Dates _____ _____ Surveyors _____ _____ _____ PIlot _____ Aircraft Type _____	Mapsheet _____ Agency _____ Survey Objectives _____ _____ _____ Survey Transcript Available ☐ Yes ☐ No Survey Report Available ☐ Yes ☐ No

flight line location is as important as the referenced animal locations along it, because the flight line is the only record of the areas that along the flight path followed. Although this map represents only one point in time, it does become a document for future reference, as it is a part of a standardized data base showing geographic distribution. The flight line location is as important as the referenced animal locations along it, because the flight line is the only record of the areas that have been searched regardless of any animal use sighted. When quantifying habitat use it is necessary to search all areas equally in order to build a habitat use model, for example if observations are only recorded on wetlands then it is not possible to compare these to the habitat types between wetlands.

The scale of the map on which the observations are recorded and the precision with which these are located will determine, to a large extent, the future level of detail that can be quantified regarding habitat use if no other observations on habitat use are recorded with the census flights. If, for example, census information is recorded on topographic maps at scales of 1:250 000 then the habitat units which can be delineated are restricted to habitat maps of this same scale.

In the future it is anticipated that a case for protecting or enhancing a site for a certain species will to a large extent depend on data that shows the degree to which the species uses and requires the site or other comparable sites as a part of it's annual cycle.

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CHAPTER 3 CARIBOU POPULATIONS

3.1 CARIBOU POPULATION DISTINCTIONS IN THE SPATSIZI WILDERNESS PARK AREA, BRITISH COLUMBIA

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INTRODUCTION

I have been involved in a radiotracking study of caribou in the Spatsizi Wilderness Park area, northern British Columbia, since October 1980. The objectives, rationale and methods for that work have been described in detail elsewhere (Hatler 1983, Hatler in prep.). In fulfilment of the terms of reference prepared by the organizers of this workshop, the purpose of this paper is to deliver some "insights" which the Spatsizi studies have spawned, and which seem to be "unique or...relevant to other studies".

Before embarking on that task, however, I can't resist some reflection on that term "insight" as it applies to our management and research endeavours. My dictionary defines it as "a clear understanding of the inner nature of some specific thing" and stresses that intuition is the primary vehicle by which that understanding arrives. Intuition is, in turn, defined as something known or learned "without the use of conscious reasoning" (Guralnik 1984). It would appear, therefore, that insights are things we know or think we know, but which do not necessarily require support by either direct evidence or thought. As a former management biologist and a colleague to several people on the participant list of this meeting, I have no qualms in stating that too much management in British Columbia, and probably elsewhere, is on the basis of such individual insights and intuition. Presumably, we hope, meetings such as this represent a move toward some happy future time when insights can be replaced by more supportable knowledge.

Finally, to conclude my insight on insights, I must confess that in conjuring mine in the following pages I have, to some extent, cheated. They are based on observations associated with 840 radio locations recorded over the 49 month period through November 1984, and considerable conscious thought about what all those observations might mean. I therefore offer them as tentative conclusions and hypotheses rather than as insights in the dictionary definition sense.

In my former capacity as a regional biologist, I was often frustrated in my management deliberations by lack of specific information about the animals I was dealing with in relation to the geographical areas I was responsible for. In addition to the usual questions relating to recruitment, mortality, numbers and trend were others about annual and seasonal distribution, especially in relation to administrative boundaries and various habitats. Recently, Stevenson and Hatler (1985) have described some caribou management problems in detail, and have identified two major needs: 1) "...a reliable and consistently applied inventory system." 2) "...identification and

description of actual populations..., as defined by functional rather than geographic criteria". The Spatsizi studies have addressed both. Aspects of inventory will be discussed in a paper to be presented later in this workshop. The present paper focuses on the matter of defining and identifying adjacent populations, based on observations of annual and seasonal movements, distribution and dispersion of radiocollared animals.

THE STUDY AREA AND ANIMALS

Figure 1 portrays the core study area in the Spatsizi Wilderness Park area, including three upland rutting areas in which fall surveys are regularly and routinely carried out. Also shown are capture locations for the 54 animals which have been collared during the study. That total sample consisted of 38 females and 16 males, but poor collar retention and some early mortality among males resulted in keeping that component smaller than originally planned (0-3 males vs. 4-8 females in the first cohort, through mid-October 1982, and 4 males vs. 18-24 females through November 1984). For that reason, the following statements and conclusions mostly refer to females unless noted otherwise. All are based on data analyzed and described in detail in Hatler (in prep.).

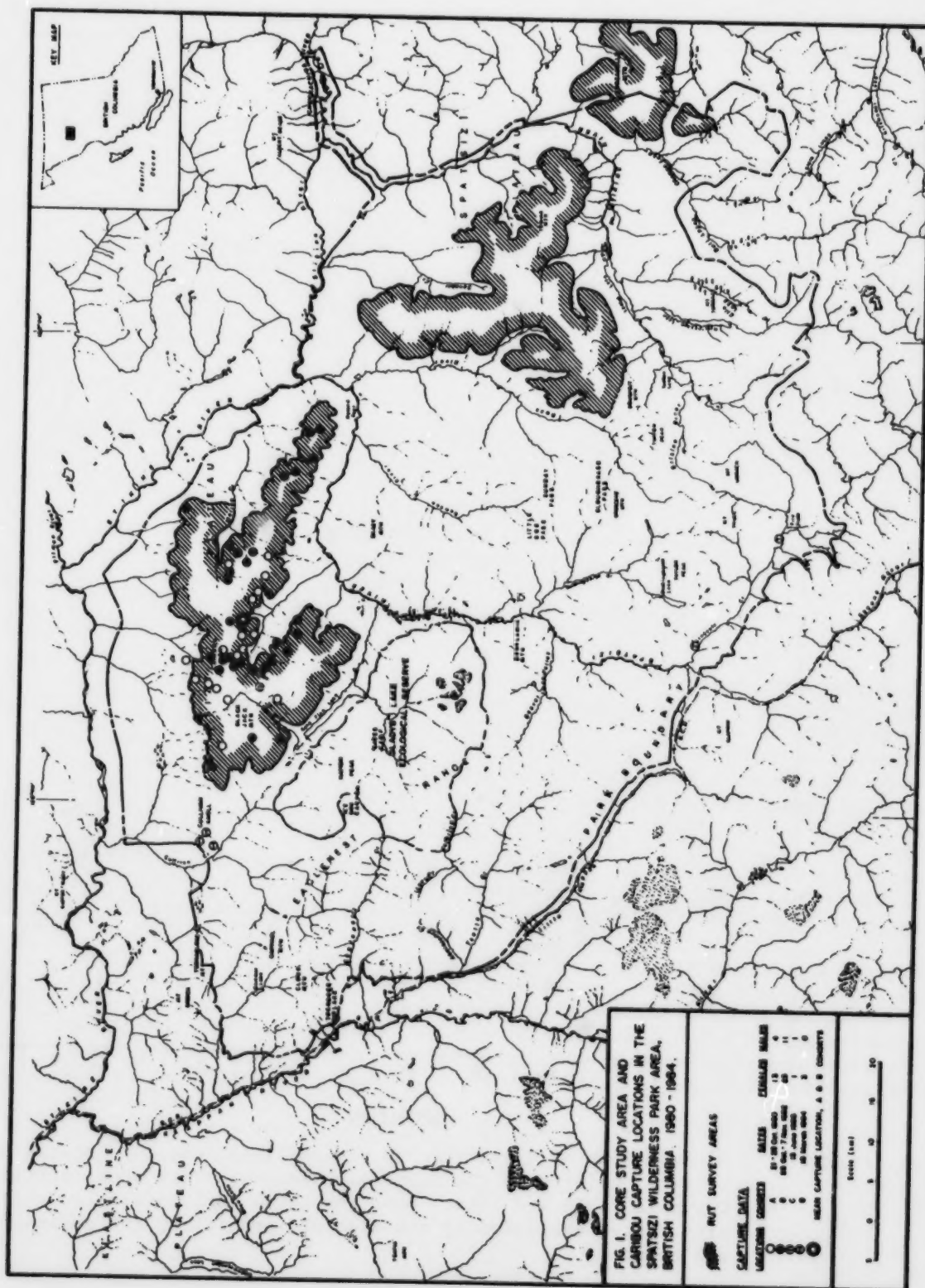
RESULTS

Distribution and Dispersion

As shown in Figure 1, all but five of the instrumented animals were captured on or near the northernmost rutting area, here termed Caribou Mountain, a few weeks after the rut periods of 1980 and 1982. The collared animals have radiated out from that area such that, during the four years through 1984, regular use of areas up to 20 km north of the northern extent of Figure 1 has been recorded and one movement 90 km off the map in that direction has been documented. Westward movements have not gone beyond the area shown, but some animals have regularly used areas up to 20 km beyond the southeastern corner. The initial impression from those occurrence records, without regard to seasons or individuals, is one of a single continuous population ranging over the entire area indicated above.

Figure 2 introduces a seasonal component, showing relative dispersion of the collared animals over all tracking flights during the last two years of study, when the sample consisted of from 26 to 29 animals of both sexes. The total minimum areas occupied by the collared animals located on each flight are shown, but the primary comparison between years is on the basis of 90% ranges, i.e., after deletion of the most extreme 10% of locations in each case.

The general pattern was similar for both years, and is consistent with expectations relative to movement data. Most of the animals, with numerous uncollared companions, occupied a total area of less than 2000 km² from about December through early May. They then dispersed to an immense area of over



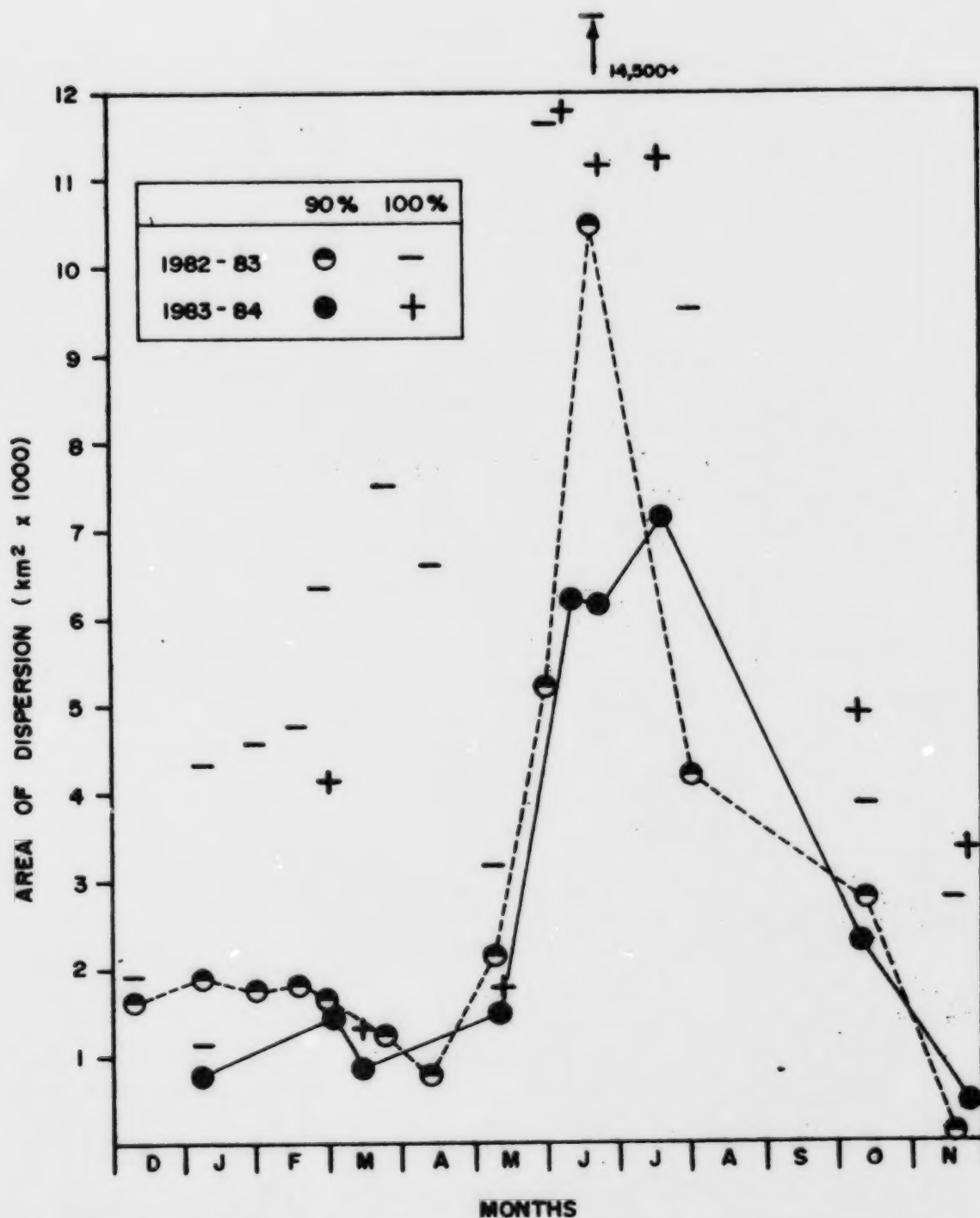


FIGURE 2. Minimum area of dispersion of radiocollared caribou located on tracking flights in the Spatsizi Wilderness Park area, British Columbia, 1983 and 1984. Both the total implied area and the 90% area (after exclusion of the most extreme 10% of the observations) are shown.

10500 km² in June 1982 and at least 6000 km² at the same time in 1984. By the time of October rut surveys in both years, most of the animals had moved back to within an area of less than 3000 km², and surprisingly, by mid-to-late November most were contained within an area of less than 500 km² in the vicinity of Caribou Mountain.

This annual pattern (Figure 2) is also believed applicable to 1981 and 1982, although with smaller amplitudes because of smaller numbers of collared animals available for locating in those years. There is some indication that the animals may have been relatively more dispersed in winter during the first two years, when snow conditions were most severe.

Annual Cycle

The nature of approximate timing of major events in the annual cycle, in relation to the dispersion pattern described above, can be briefly summarized as follows:

Winter - as shown, the animals have been most concentrated (least dispersed) from November through about mid-May. They have also tended to be relatively sedentary at that time, especially during the later months, but with some variations to that pattern, apparently in response to climatic factors.

Spring migration - the most dramatic and extensive movements have been by females enroute to calving areas from the winter range. They have apparently started in early to mid-May, the timing probably depending upon phenological factors, but most have completed that movement by the end of May. There is some indication that males leave the winter areas a month or more later than females and/or move more slowly to summer areas, but that may vary with different destinations.

Calving - most calves have been born between the last few days of May and mid-June, with an apparent peak from about 3-8 June. That peak corresponds to the peak annual dispersion documented in 1982-83 and 1983-84 (Figure 2).

Summer - the trend in early summer, through July, has been for movements and aggregation, reducing total dispersion, but females with calves have been less prone to that tendency than those without. There have been relatively few observations in August and September, but it is implied that continued aggregation and movements to alpine areas, including those used during rut, have been the rule (again excepting a proportion of females with calves).

Rut - the peak of rut has not been firmly established, but based on the observations of Bergerud and Butler (1978) and experience during fall surveys since that time, the second week of October is regarded as fairly close. Concentration on the various rutting areas has reduced dispersion considerably over that pertaining in summer, but still higher than that observed in winter (Figure 3).

Post-rut fall migration - following the rut, there has been a general convergence of collared animals to uplands in the Caribou Mountain area, which is adjacent to the primary wintering area in the Stikine Valley. The commencement of movement probably varies with weather conditions and distance from rutting locations, but by the third week in November as noted earlier, the lowest annual dispersion (i.e., highest concentration) of the year has been recorded. Following that concentration, the animals have then started a limited but continuing dispersal over the wintering area.

INDIVIDUAL RANGE AFFINITIES

Preceding accounts have described general spatial and temporal behaviour patterns exhibited by the collared animals as a group. However, repeated observations of the collared animals as individuals demonstrate that despite their relatively close association in the Caribou Mountain area in November and in the Stikine River valley area for the remainder of the winter, they do not function as a group all year. Individuals differ in the extent of their movements to the summer area, and therefore in the sizes of their annual and total "home ranges" (Harestad 1981), and they also vary in their degree of fidelity to the summer area.

Home Range Patterns

The home range data, though variable in comparisons between individuals, produced the first evidence of separate summer range affinities in the area. In a comparison between the two fall-captured cohorts of collared animals (see Figure 1), I found that the 1982 animals had much larger mean annual ranges than the 1980 group. Furthermore, many of the cumulative 2-year ranges for the 1982 cohort equalled or exceeded the 4-year ranges for the 1980 animals. It was evident that the distance between the winter and June location, i.e., the length of the spring migration, was the primary factor contributing to the differences in home range size. The smallest ranges were for those animals which remained in the general vicinity of the Spatsizi River drainage above Ross River and the drainage of the lower Stikine River below its confluence with the Spatsizi. Intermediate sized ranges were recorded for those in the upper Ross/upper Stikine areas, and the largest ranges were for outliers and/or individuals with no apparent attachment to a particular early June location. The observed difference between cohorts can be explained by the differences in timing between the 1980 and 1982 capture expeditions in relation to the post-rut migration described earlier. Most of the 1980 captures were earlier

than those in 1982, thus biasing the sample to a greater degree to those individuals which had summered or rutted nearby.

Fidelity to June Location

The factor which insures the continuity of the home range size pattern described above is the tendency for individuals to return to the same area each spring. Figure 3 shows early June locations for all animals contacted at that time during the four years of study, and indicates yearly locations applicable to individuals. In general, parturient females have showed the strongest homing tendency, some returning to within meters of previous year's locations. Even in the case of fairly long distances between successive June locations, only a few animals have alternated between the two general summer areas described earlier. Observations in 1985 (Hatler unpubl. data) have further strengthened the view that the dominant tendency for pregnant females, at least, is to return to calving areas of previous years. There is an indication (Figure 3) that barren females and males may occasionally exhibit that behaviour as well.

Relationship of June and Rut Locations

The accumulating evidence is that commitment to a particular location in June also essentially determines the general rut location. The term "general" in the previous sentence refers to the fact that not all rutting occurs on the three upland rut survey areas indicated in Figure 1. Members of the Upper Spatsizi-Lower Stikine group (short distance movers) rut on Caribou Mountain or in outlying areas within that summer range area, while the more southerly Upper Ross-Upper Stikine-Kluayaz animals (long distance movers) rut there, apparently mostly in the Tomias Mountain area. There is a third group in the area which has been represented by only two collared animals which have been monitored for more than one year. That group includes numbers of calving females in the mountains southeast of Spatsizi Park, in the Tatlatui Park-Lawyers Pass-Upper Finlay River area. Rutting also occurs at several locations there, including the Edozadelly Mountain rut survey area. At least some individuals from this southernmost group move north to the lower Stikine wintering area, but wintering also occurs in the Finlay drainage in at least some years.

CONCLUSIONS ("INSIGHTS")

- 1) The emerging picture is that the homing tendency of many individuals in spring and subsequent local movements in summer result in maintaining adjacent rutting groups which remain largely separate. There appear to be at least three such groups in the Spatsizi-Tatlatui Park area, although a larger sample of collared animals might reveal more. Whether those essentially separate groups constitute "populations" in the sense of distinct units for management and/or research is a question we may not yet know enough to answer. The term "herd" as used by Calef (1978) to refer to

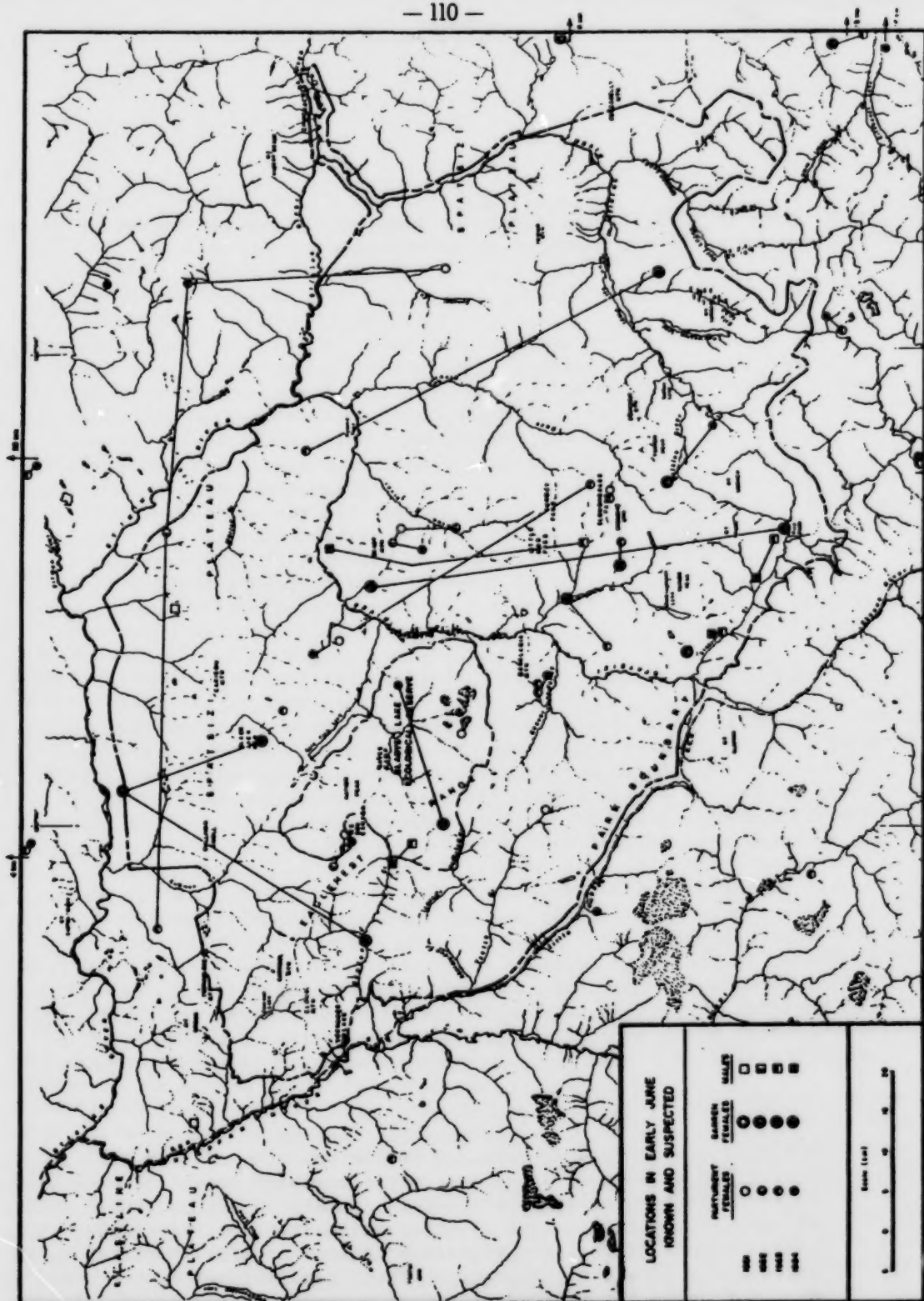


FIGURE 3. Early June distribution of radiocollared caribou in the Spatsizi Wilderness Park area, British Columbia, 1981-1984. The terms "known and suspected" in the legend apply to maternal status (parturient or barren), as described in Hatler (in prep.). Lines connect early June locations for the same individuals in different years.

a group of barren-ground caribou sharing a common calving ground and by Bergerud (1978) to refer to particular rut area associations of B.C. caribou would seem a better choice, with "population" referring to the collection of herds sharing a common winter range. With that definition, the Spatsizi population overlaps all of two provincial parks and portions of at least 6 management units in three administrative sub-regions of the province.

- 2) In another recent long term study of radiocollared woodland caribou, Edmonds and Bloomfield (1984) have described a situation in western Alberta similar to that portrayed here. They identified two adjacent groups of caribou which apparently shared a winter area to at least some extent, but which remained separate during the summer and fall period. As in Spatsizi, their two groups were distinguished by long and short distance movers from the winter range rather than by equally long or short movements in different directions.
- 3) If woodland caribou populations generally support two or more groups of "morphs" with different movement tendencies, as observed in the Spatsizi and Alberta studies, there are some management implications:
 - a) The long distance movers are probably most vulnerable to human impacts, due to increased likelihood of contact, especially in the case of linear developments such as roads, railroads and reservoirs. It is possible that many of the apparently sedentary groups of caribou in southern B.C. are remnant populations in which the movers have been selected out.
 - b) Overall population size probably can not be maximized without both morphs in the population; therefore management goals of increase may not be realizable for some populations in some areas.
 - c) Transplant efforts may fail if sedentary morphs are moved to areas where movers are required, and vice versa.
 - d) If the tendency to move and selection of a summer location is learned from the mother, early summer human activities may interrupt and destroy local traditions.
- 4) For proposed radiotelemetry studies, the timing and location of capture programs should be planned to insure a sample best suited to fulfil study objectives. For example, a sample captured on winter range may or may not include representatives from an adjacent summer area which the researcher hopes to study.
- 5) The main winter range for the Spatsizi population is largely outside of park boundaries, but as the only area regularly shared among two or more adjacent herds, it seems particularly important.

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3.2 EARLY CARIBOU CALF MORTALITY IN NORTHWESTERN BRITISH COLUMBIA*

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Abstract

Thirty four newborn caribou calves were collared with mortality sensing radios in two study areas in Northwestern British Columbia. In 1979, calves suffered 60% mortality in the first month and 80% to 4 months. In 1980, mortality rates were 20% in the first month and 50% to 4 months. Wolf and grizzly bear predation were the primary mortality factors. The difference between years was hypothesized to be due to snow melt patterns that restricted the distribution of calving females in 1979 and increased predation rates. A minimum of 35% survival to the fall is necessary to balance adult mortality. Survey data indicated that excess predation on calves has been frequent over the last decade, leading to a decline in total number of caribou in the region.

Discussion

In the first year at least, very few of the collared calves survived the summer study period. Collaring itself did not appear to produce the pattern of mortality observed. There was no abandonment by females in either year, despite contamination by human scent in 1980. Mothers seemed to identify their calves first aurally, then visually, and only then by smell (Page and Bergerud 1979). If human scent reduced predation, lower rates of predation would have been expected in the first few days after collaring. Finally, and conclusively, survival of collared calves was the same as uncollared calves, as evidenced by fall rut surveys. In 1979, 9% calves was expected from the collared sample and 9% was found in the fall survey. On Level Mt. in 1980, 19% were expected and 16% were surveyed (Figure 1). The collared calves were an unbiased sample.

Our focal point is the hypothesis that sufficient calves are recruited to balance adult mortality. Adult mortality rates in this study were not measured and other attempts at life table analysis have been unsuccessful (Miller 1974, Doerr 1980). However, Bergerud (1980) estimated the natural mortality of adult caribou in North America to vary from 7 to 13 percent with a mean of 10 percent. There is an inverse correlation between adult mortality rates and percent calves in the population due to shifts in predation (Bergerud 1982). The estimated natural mortality of adult caribou in NW British Columbia during the years studied was at least 12% with an additional 2 - 3% hunting mortality (Bergerud and Elliott in press). Current work indicates that adult mortality could possibly be closer to 20% (Hatler 1983, Edmonds and Bloomfield 1984,

* extracted and modified by the author from Page, R. E. 1985. Early caribou calf mortality in Northwestern British Columbia. M. Sc., Dept. Biol., Univ. Victoria, Victoria, B. C. 143 p.

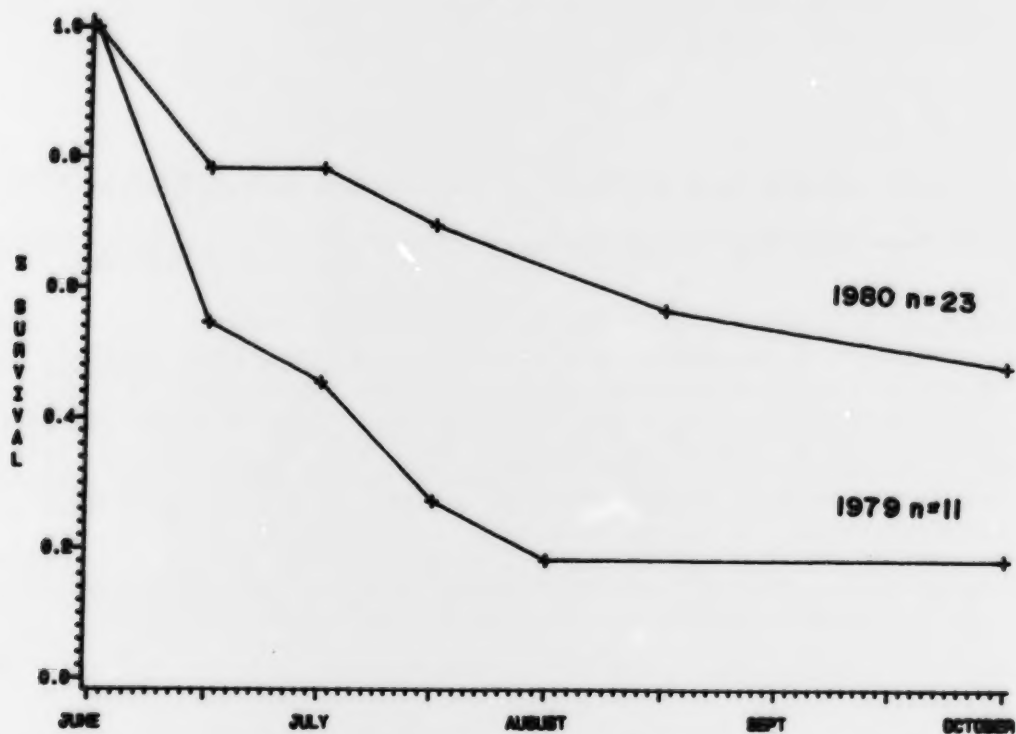


Figure 1. Survivorship curves of collared calves.

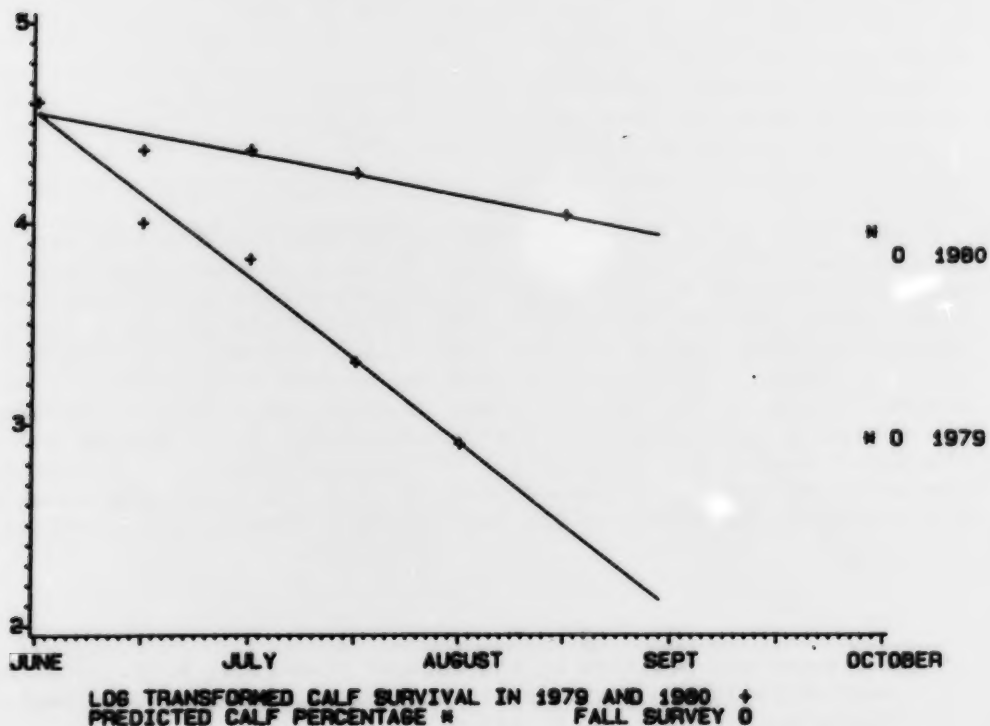


Figure 2. Logarithmic survivorship curves of collared calves.

Fuller and Keith 1980), but results are preliminary. Only one mother of a collared calf was known to have died, and that was in an avalanche. Adult mortality did not appear to be excessively high during the summer study period. To be conservative, a minimum of 15% calf recruitment would be necessary to maintain population levels (Bergerud 1978).

Recruitment is defined to be the number of animals at one year of age, but we only obtained data until 5 months. After the summer study period, calf survival increased dramatically, (Figure 2) more closely approximating adult survival rates. Bergerud (1980, 1982) estimated overwinter calf mortality to be twice that of adults. This estimate agrees with a sample of the Delta herd in Alaska where overwinter survival was 80 - 92% (Davis *et al.* 1980). Spring yearling counts were consistently higher than fall calf crops (Elliot *et al.* 1984), probably due to differential movements of the herd in spring, so could not reliably indicate recruitment rates. Still, recruitment was less than 8% in 1979 and less than 15% in 1980. In these two years, recruitment was insufficient to balance adult mortality. The hypothesis is rejected.

The alternate explanations to the hypothesis are limited. Calves might not be born, yet spring udder counts indicate that 86% of the females gave birth (Table 1). Pregnancy rates of caribou are essentially constant (Bergerud 1980) in all but cases of extreme and chronic food shortages (Thomas 1982). Caribou do not have twins (McDonald and Martell 1981, Mc Ewan 1971). The calves could conceivably die after birth from malnutrition. Rather than being malnourished however, all captured calves were large and vigorous. In fact, the smallest newborn calf in this study at 5.0 kg was the mean weight for the Kaminuriak herd (Miller and Broughton 1974). Large birth weight is indicative of good maternal nutrition during pregnancy and is correlated with high survival (Haukoija and Jalovaara 1978, Verme 1963, Verme 1977). Heart girth of females was similar in spring and fall indicating that fat reserves were not totally depleted overwinter (Table 2). Low fertility is rejected as an explanation for poor recruitment.

There was also no sign of the diseases mastitis or besnoitosis in adults that could have reduced milk production leading to starvation of calves. Calves vigorous at birth could later succumb to disease, but cultures from newborn calves, and the few carcasses that could be recovered, indicated no disease organisms present in unusual abundance, with the exception of the ubiquitous *E. coli*. One calf (05-80) may have suffered from heavy *E. coli* O-group infection as reported to have caused death in West Greenland reindeer calves (Claussen *et al.* 1980). In reported cases though, death required at least 8 days and disease symptoms were obvious, both pre- and postmortem. This calf died in 3 days and showed no indications of disease on gross examination and necropsy, and leucocyte counts were not elevated. Death due to a massive infection of *E. coli* is unlikely to have been the cause. No disease agent appears to be implicated in the decline.

Table 1. Productivity of female caribou from spring aerial surveys.

	Date	Total Females	Udders No	Yes	Calves	% Parous
1979						
Mountains	3-12 June	40	3	37	34	92
	14 June	13	2	11	6	85
	15 June	12	8	4	1	33
	18 June	10	2	8	3	80
Fire Flats	19 June	12	3	9	0	75
	21 June	2	1	1	0	50
	22 June	5	2	3	0	60
	23 June	1	0	1	0	-
	24 June	42	8	34	2	81
	25 June	5	1	4	0	80
	26 June	19	8	11	1	58
	28 June	1	0	1	0	-
	Total		162	38	124	47
1980						
	2 June	15	3	12	6	80
	4 June	34	9	25	11	74
	5 June	35	7	28	14	80
	6 June	17	2	15	13	88
	7 June	17	0	17	15	100
	8 June	13	0	13	13	100
	10 June	42	6	36	29	86
Total		173	27	146	101	84

Table 2. Adult Physical Characteristics.

#	Date	Calf	WT	EA	HE	NE	SH	HG	LN	TA	FT	Udder LXWDXD
Spatsizi - Spring 1979												
Females												
04	June 5	03		11	41	65	137	142	216	18	-	17 10 10
05	June 6	Y		13	46	50	132	134	218	19	61	15 13 10
08	June 7	07		18	38	45	122	118	193	15	57	12 10 10
14	June 8	13		15	45	58	117	132	182	21	58	12 10 10
15	June 25	N		14	41	41	122	117	199	10	57	none
101	May 27	102	148	15	43	46	118	121	200	17	59	10 10 2
Level Mt. - Spring 1980												
Females												
12	June 5	11		16	32	51	127	127	222	20	61	18 12 9
23	June 8	22		15	44	48	108	130	210	17	61	18 10 7
Spatsizi - Fall 1980												
Females												
00	Oct 21	Y	145	15	48	62	112	137	204	20	57	16 9 10
01	Oct 22	N		17	43	56	105	136	193	17	59	none
02	Oct 23	N		13	44	58	117	136	197	11	56	none
03	Oct 23	N		15	42	53	121	127	191	18	56	none
04	Oct 24	no data										
05	Oct 24	Y		13	44	50	118	123	212	19	59	16 9 6
06	Oct 25	N		16	48	63	118	136	217	16	66	none
07	Oct 26	Y		13	45	54	124	129	206	15	57	small
08	Oct 27	N		13	44	62	122	141	203	16	55	none
09	Oct 28	N		15	42	61	117	134	211	15	61	none
10	Oct 23	no data										
11	Oct 28	N		15	41	63	124	136	201	13	60	none
Males												
13	Oct 23			16	44	74	125	142	214	16	60	
14	Oct 24		188	14	46	67	113	137	221	19	62	
15	Oct 25		263	15	52	78	142	144	228	20	63	
16	Oct 27			16	47	80	140	138	220	19	64	
Females - means			146	15	43	52	120	131	204	16	59	
Males - means			226	15	47	75	130	140	220	18	62	

Table headings:

Calf - Present (Y) (calf number if captured), or Absent (N)
 WT - weight
 EA - length of ear
 HE - length of head
 NE - circumference of neck
 SH - shoulder height
 HG - heart girth
 LN - total length
 TA - length of tail
 LN - hind foot
 LXWDXD - Length, Width, Depth of Udder

Calves did not disperse. All collared calves remained in the study area for the summer. Indications were that after migration to wintering areas, they returned to the mountains of their birth. Females in Spatsizi show strong fidelity to a specific calving mountain (Hatler 1983).

Other studies have suggested from circumstantial evidence, that calves may die in inclement weather, even though cold cannot kill adults (Kelsall 1968, Kudryashova 1980). No collared calves in this study died due to weather stress. The worst day of weather in the two years was June 5, 1979 coincident with the peak of calving. Though wind gusts reached 70 km/hr, average cumulative wind speed for the day was only 7.0 km/hr/hr at a low temperature of -4°C , insufficient to cause death. Death from windchill has been suggested to have killed caribou calves in the Arctic (Kelsall 1968), but wet coats, high winds and freezing temperatures for prolonged periods were required. These conditions do not exist in British Columbia. If calves are able to use microclimate, or bed to avoid the wind, no mortality occurs at temperatures of -5°C and winds of 56 km/hr (Hart *et al.* 1961). Calves in Spatsizi bedded against the downwind side of the female to maintain homeostasis and birth sites were generally in favourable microclimates. They also have the option of making altitudinal shifts up or down to avoid freezing rain conditions. Weather for the previous ten years should not have killed calves in Northwestern British Columbia, especially since calves should always be able to escape death from windchill by seeking shelter (Henshaw 1968).

The difference in calf survival between years was negatively correlated with spring snow depths. Fall calf crops were significantly lower after late springs with deep snow (Figure 3; $df=1,6$, $r=.78$, $F=11.6$, $p=.01$). With high pregnancy rates and no evidence of disease, malnutrition or intrinsically weak newborn calves, the potential adverse effects of deep snow on overwinter productivity and condition of females can be eliminated from consideration (Peterson and Allen 1974).

There was a fairly high loss of calves to accidental sources. Some loss to avalanches, birth anomalies and drowning might be expected, but the 15% loss experienced by these animals appears excessive. No individual accident occurred in the sample more than once, suggesting that the losses were random, but accidents such as avalanches and broken legs are peculiar to high elevation calving, and should be low in the forested areas.

Some females in these populations do calve in the shrub and forest zones, which appear to be the preferred calving areas for other populations (Fuller and Keith 1980, Oosenbrug and Theberge 1980). Apparent selection in those studies may be a lack of choice. Alpine areas are not available to Alberta caribou and the Burwash herd in the Yukon, 300 km north of Level Mt., may be excluded from calving in the alpine by spring snow cover. Strong pressures must be operating to force the females in this study to calve at extreme elevations.

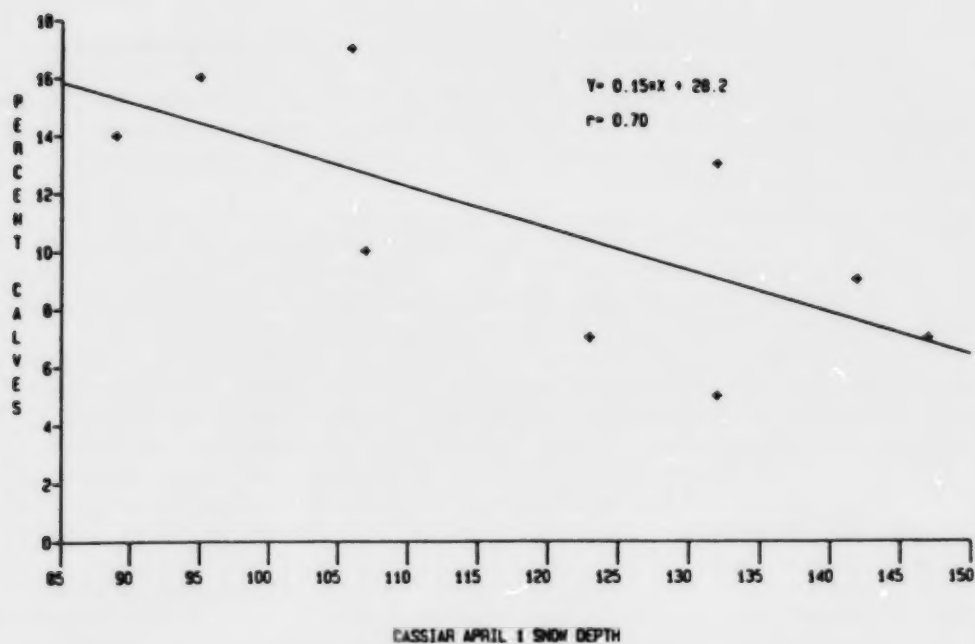


Figure 3 Correlation of Spatsizi fall calf numbers and spring snow depths.

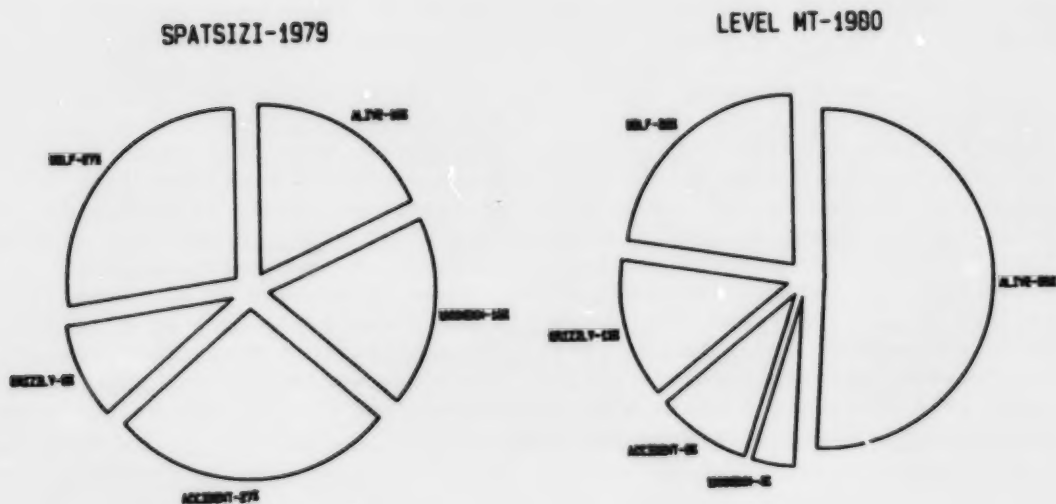


Figure 4. Fate of collared calves.

The obvious selection pressure for alpine calving is predation (Bergerud et al. 1984, Elliot et al. 1984). At least 50% of the deaths of calves was due to predation by grizzly bears or wolves (Figure 4). In 1979 in Spatsizi, predators moved in from surrounding areas and scoured every mountain in the calving area. Grizzlies, in particular, intensively searched the alpine area.

There was little or no alternate prey for predators in these high alpine areas. Grizzlies never hunted marmots and were observed to traverse marmot colonies without pausing. Green vegetation for grizzlies was only available at lower elevations, yet they forsook this abundant and nutritionally adequate food source (C. Jonkel, pers. comm.) to hunt high alpine for caribou calves. It appeared on Level Mt. that grizzlies were also in the alpine to find mates and so remained at high elevations despite low hunting success. Wolves were primarily dependent on moose, which are only found below treeline. Both grizzlies and wolves had to choose to leave other food sources and rely exclusively on their ability to hunt caribou calves.

Female caribou are not able to defend their young against predators as large as wolves and bears, so are choosing to distance themselves from these threats to their offspring in favourable escape terrain (Bergerud et al. 1984). As calving approaches, female caribou move toward high elevation alpine areas and disperse from each other, to minimize encounter rates with predators. The array of predators (wolves, grizzlies, wolverines and golden eagles) must search much greater areas in years of no snow, than if females are concentrated by snow or are in calving herds. Predators must expend greater energy hunting mountains than valleys, and may not detect calving females above them due to rising air currents. The strategy of alpine calving is a good one, given the alternatives.

The ultimate cause of the decline of the caribou of Northwestern B. C., that began in the early 1970's may not ever be known (Bergerud 1978, Bloomfield 1979). By the end of the decade, when this study began, the overwhelmingly significant factor responsible for continued loss of herds and the decline of populations was excessive levels of predation, primarily on calves in the first three months of birth. Many other studies have documented population declines or limitation from heavy neonatal predation, for caribou (Bergerud 1971), moose (Franzmann et al. 1980, Ballard et al. 1981) and deer (Carswell and Brown 1977, Cook et al. 1971, Smith and Lecount 1979, Hatter 1984). The magnitude of predation losses in Northwestern British Columbia during this study was sufficient that if all other calf mortality factors were controlled, and hunting was halted, the populations would continue to decline.

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3.3 PRELIMINARY RESULTS OF THE QUESNEL LAKE CARIBOU STUDY

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The Quesnel Lake caribou study was initiated in 1984 to determine the effect of logging on woodland caribou populations (Rangifer tarandus caribou) in central British Columbia. Caribou populations are being compared in logged and unlogged areas. The objectives of the study are:

1. To determine the seasonal habitat use and food habits of the caribou.
2. To determine the major limiting factors of the caribou populations, particularly the relative importance of nutrition and predation.
3. To determine if logging has negative effects on the caribou population by: i) increasing predation, ii) decreasing nutrition, iii) increasing poaching, or iv) causing range abandonment.

The project is in progress at this time so the results are preliminary and are presented in a brief, summarized form.

Study Area

The study is being conducted at Quesnel Lake, B.C. (52°40'N, 121°W). Biogeoclimatic zones include the Interior Cedar Hemlock Zone (ICHh) extending from the lake to about 1250 m, the Englemann Spruce Subalpine Fir Zone (ESSFh) between 1250 and 2100 m and Alpine Tundra (AT) above 2100 m (Annas and Coupe 1979). The North Arm of Quesnel Lake divides the study area into a logged and unlogged area. The area on the west side of the Arm has been extensively logged at low elevations. The area on the east side of the Arm is primarily unlogged wilderness and is contiguous with Wells Grey Provincial Park.

Methods

In March 1984, 16 adult female caribou were captured by net-gunning and radio-collared (8 in logged, 8 in unlogged habitat). In 1985, an additional 7 caribou were captured and radio-collared to replace animals which had died the previous year and to increase the sample size to 18 (9 in logged, 9 in unlogged habitat). Blood samples were collected at time of capture and analysed for plasma progesterone concentrations to diagnose pregnancy. Four wolves (Canis lupus) were trapped and radio-collared in July 1984.

The radio-collared caribou and wolves were located from the air at approximately weekly intervals. Location, elevation and habitat type were recorded for each relocation. The radio collars had a mortality sensor and caribou which died were autopsied to determine the cause of death.

Caribou fecal samples were collected at monthly intervals from the different habitat types being used by the animals at that time of year. Fecal samples were analysed for nitrogen concentrations as an index of diet quality. A composite sample from each fecal collection was analysed for

diet composition by fecal fragment analysis (Wildlife Habitat Lab., Washington State University, Pullman). Wolf scats were collected and analysed to determine the food habits of wolves. Scat composition was corrected to account for differences in prey size using the technique of Floyd et al. (1978).

Radio-collared caribou were spotted from a helicopter in mid-June to determine which ones had surviving calves. Subsequent helicopter surveys were conducted at monthly intervals throughout the summer to monitor calf survival.

Caribou were censused in early March from a helicopter. The proportion of collared animals spotted was used to correct the census results for "sightability".

Results

Habitat Use and Food Habits

Late winter: In late winter (January-April), caribou were located in subalpine spruce-fir forests as well as more open alpine forests at high elevations (Table 1). During this period, arboreal lichens and conifer browse constituted most of the diet (Table 2). The caribou were able to range widely over the winter range and did not become concentrated in small areas. Arboreal lichens appeared to be superabundant on the winter ranges.

May: In May, many, but not all caribou moved to lower elevations which allowed them to feed on new herbage production. Caribou at low elevations in May used avalanche chutes and clearings in the cedar-hemlock forests and fed on a variety of forbs and shrubs (Tables 1 & 2). Caribou which remained in the subalpine forests in May continued to feed on arboreal lichens and conifer browse but were also able to obtain mosses and other ground vegetation.

Summer: During calving in June, adult females were found at high elevations in spruce-fir forest, alpine forest and alpine habitats. In 1984, movement to high elevations resulted in a decrease in the quality of food intake compared to what was available at lower elevations (Figure 1). In 1985, caribou were able to obtain new herbage production at high elevations in June so there was no decrease in diet quality associated with the movement to higher elevations.

Caribou remained at high elevations throughout the summer, primarily using subalpine forests, particularly in areas interspersed with sedge meadows (Table 1). The diet consisted of a wide variety of sedges, shrubs, forbs and terrestrial lichens (Table 2). Although caribou often used alpine snowpatches on hot summer days, these animals were only a small proportion of the total population. Therefore, censuses of caribou on snowpatches in summer greatly underestimate the total population.

Fall and early winter: In early winter, some of the caribou remained in subalpine forests whereas others moved to lower elevations and used cedar-hemlock forests (Table 1). The caribou in subalpine forests fed on

Table 1. Habitat use of caribou in Quesnel Lake area.

Season	Elevation ($\bar{X} \pm SD$)	Habitat type	Number of relocations	Percentage of relocations
January- April	1698 $\pm$ 161	Alpine forest	100	43
		Subalpine forest	93	40
		Subalpine meadow	36	15
		Alpine	2	1
		Cedar forest	3	1
May	1482 $\pm$ 277	Subalpine forest	62	42
		Slides	33	22
		Cedar forest	29	20
		Alpine forest	20	14
		Alpine	3	2
June-Sept	1616 $\pm$ 252	Subalpine forest	121	34
		Alpine forest	82	23
		Subalpine meadow	80	22
		Alpine ^a	42	12
		Cedar forest	32	9
October- December	1572 $\pm$ 245	Subalpine forest	57	63
		Cedar forest	19	21
		Alpine forest	11	12
		Alpine	2	2
		Pine forest	2	1

^a/usually on snowpatches

Food type	May					December	
	late winter	low elevation			summer	October	cedar forest subalpine
		low elevation	subalpine	subalpine			
Arboreal lichens	41.1	3.3	44.9	12.3	33.1	2.3	36.0
Terrestrial lichens	6.2	15.0	2.5	25.5	32.9	56.3	20.5
Deciduous shrubs	4.1	14.2	3.6	12.4	2.6	16.7	3.9
Conifers	35.9	21.3	31.0	7.8	1.6	21.0	13.1
Grasses/sedges	5.4	9.7	1.0	23.2	19.3	0.0	10.9
Forbs	2.7	35.2	1.0	15.0	2.6	1.0	2.7
Mosses	4.5	1.3	16.0	2.6	3.8	1.0	10.1

arboreal lichens and conifer browse. Caribou in the cedar-hemlock forest fed on terrestrial lichens, forbs and browse in the shallow snow areas at the base of the trees. The diet quality was not different between the high and low elevation habitat types (Figure 1).

Population Parameters

Population size: During the winter census, 9 of 12 collared caribou were spotted indicating that we were seeing about 75% of the animals. A total of 118 caribou were spotted. Therefore the estimated population for the study area was 150 animals which corresponds to a density of about 1/10 km². It is likely that a similar density of caribou extends beyond the boundaries of the study area. The estimated caribou density did not differ between the logged and unlogged side of the study area.

Calf production and survival: All adult females had plasma progesterone concentrations exceeding 3.0 ng/ml (4.3 - 11.3 ng/ml) when captured which indicates that they were all pregnant (Rehlinger et al. 1981). In addition, four adult females which were autopsied in winter were pregnant. These results suggest that the pregnancy rate for adult females is close to 100%.

In 1984, 39% of adult females had surviving calves in mid-June compared to 55% with surviving calves in mid-June 1985. None of the radio-collared caribou had calves survive throughout the summer of 1984 when wolves were present on both sides of the study area. In 1985, 0 of 6 calves survived in the area with wolves compared to 5 of 5 calves surviving in the area without wolves (Table 3, Fig. 2).

Adult mortality: Ten radio-collared adults died during 34 caribou/years of monitoring. Therefore the annual adult mortality rate is about 30%. All the mortalities were due to natural causes and half were due to predation by wolves and bears (Table 3).

Wolf Ecology

Two of the radio-collared wolves belong to a pack of 6-8 animals which range over the entire study area. In 1984, the wolf pack lived on the logged side of the study area and there was evidence that other wolves were living on the unlogged side. In 1985, the wolf pack which contained the radio-collared wolves moved to the unlogged side and throughout the summer there was no evidence of wolves on the logged side of the study area.

During the winter months all wolf relocations were at low elevations in cedar-hemlock forests, clearcuts and burns (Table 4). Therefore there was no habitat overlap between caribou and wolves in the winter. During the summer months, wolves were regularly found at high elevations in areas that were inhabited by caribou. Wolf scat analyses indicated that moose, deer, snowshoe hares and small mammals comprised the majority of the diet (Fig. 3). Caribou constituted only a small part of the diet.

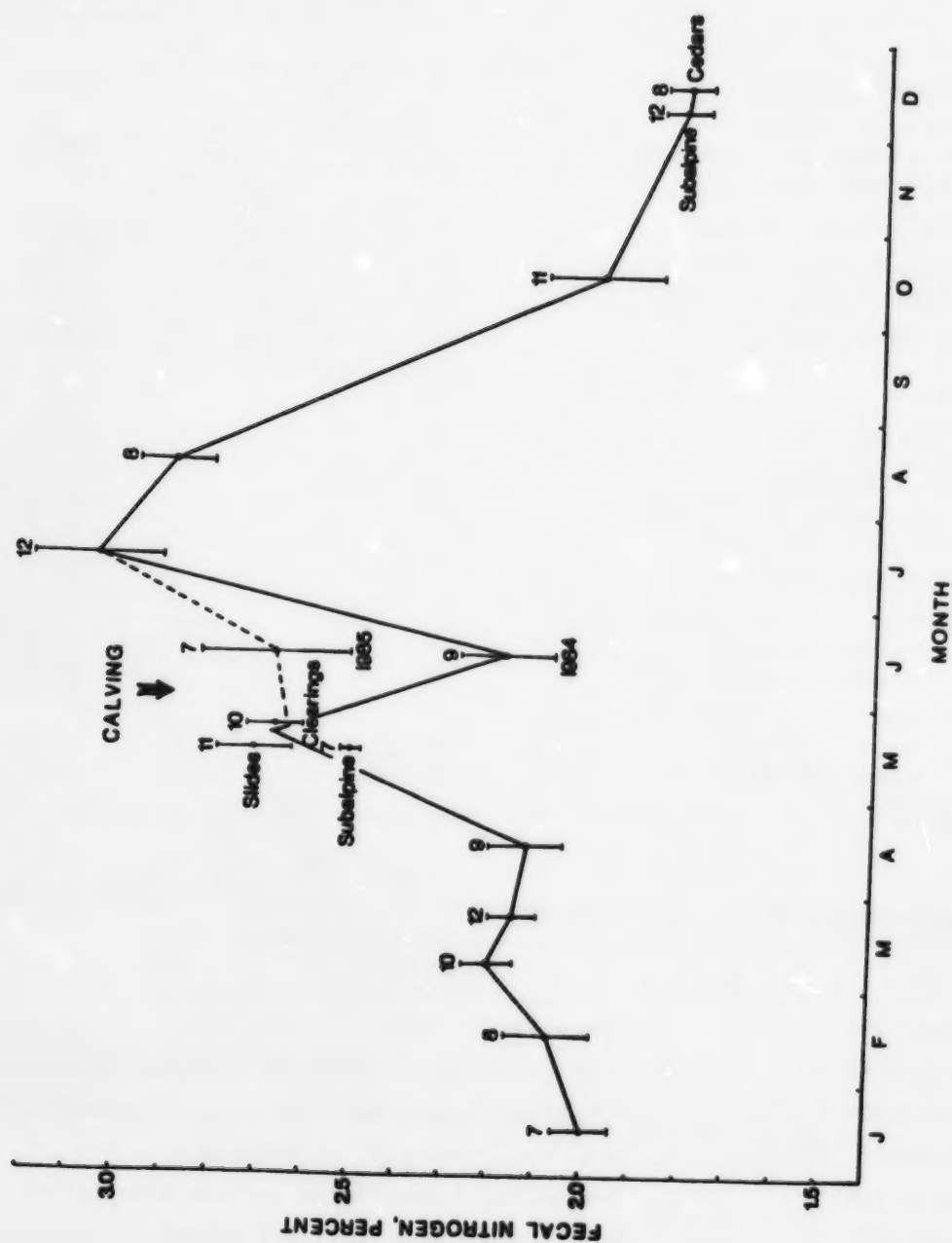


Figure 1. Fecal nitrogen concentrations ($\bar{X} \pm SE, n$) for caribou in the Quesnel Lake area. Samples were collected in subalpine habitat unless labelled otherwise.

Table 3. Calf survival and adult mortality of caribou.

Date	Cows counted	% cows with calves
1984:		
Pregnancy rate	17	100.0
Cows with calves		
mid-June, collared cows	13	38.5
mid-June, all cows	28	39.2
late June, all cows	36	33.3
late August, collared cows	11	9.1
late August, all cows	18	5.5
October, all cows	36	<11.0
1985:		
Pregnancy rate	9	100.0
Cows with calves		
mid-June, collared cows	17	65.0
mid-June, all cows		55.0
mid-July, all cows	18	50.0
August, collared cows		
wolves present	6	17.0
wolves absent	9	56.0
November, collared cows		
wolves present	6	0.0
wolves absent	9	56.0

Adult mortality:

Date	Cause
June 1984	predation by bear
July 1984	starvation, predisposed by predator avoidance
July 1984	predation by wolves
December 1984	accident leading to starvation
March 1985	avalanche, 4 uncollared caribou also killed
June 1985	wolf predation by collared wolves
August 1985	killed or scavenged by bear, unhealthy caribou
December 1985	unknown
December 1985	wolf predation
January 1986	unknown predator

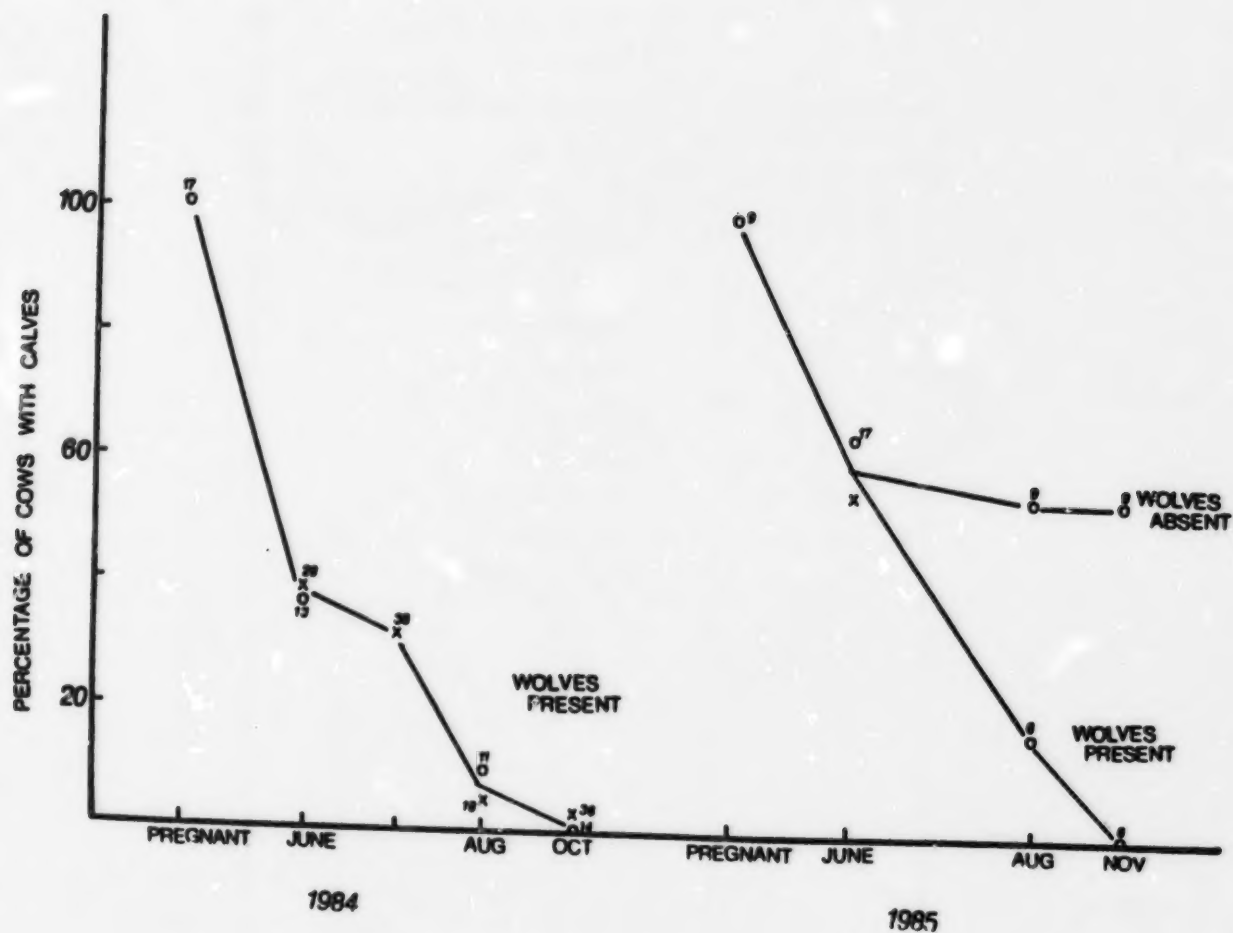


Figure 2. Survivorship of caribou calves and the effect of wolves on calf survival. (o collared cows, x all cows)

Table 4. Habitat use of wolves at Quesnel Lake.

Season	Elevation $\bar{X} \pm SD$	Habitat type	Number of relocations	% of relocations
September- May	1073 $\pm$ 224	Logged cedar forest	30	46
		Cedar forest	14	22
		Burns	14	22
		Subalpine forest	5	8
		Pine forest	2	2
June-August	1266 $\pm$ 391	Logged cedar forest	12	29
		Subalpine forest	11	26
		Cedar forest	8	19
		Alpine forest	3	7
		Alpine	3	7
		Burns	3	7
		Pine forest	2	5

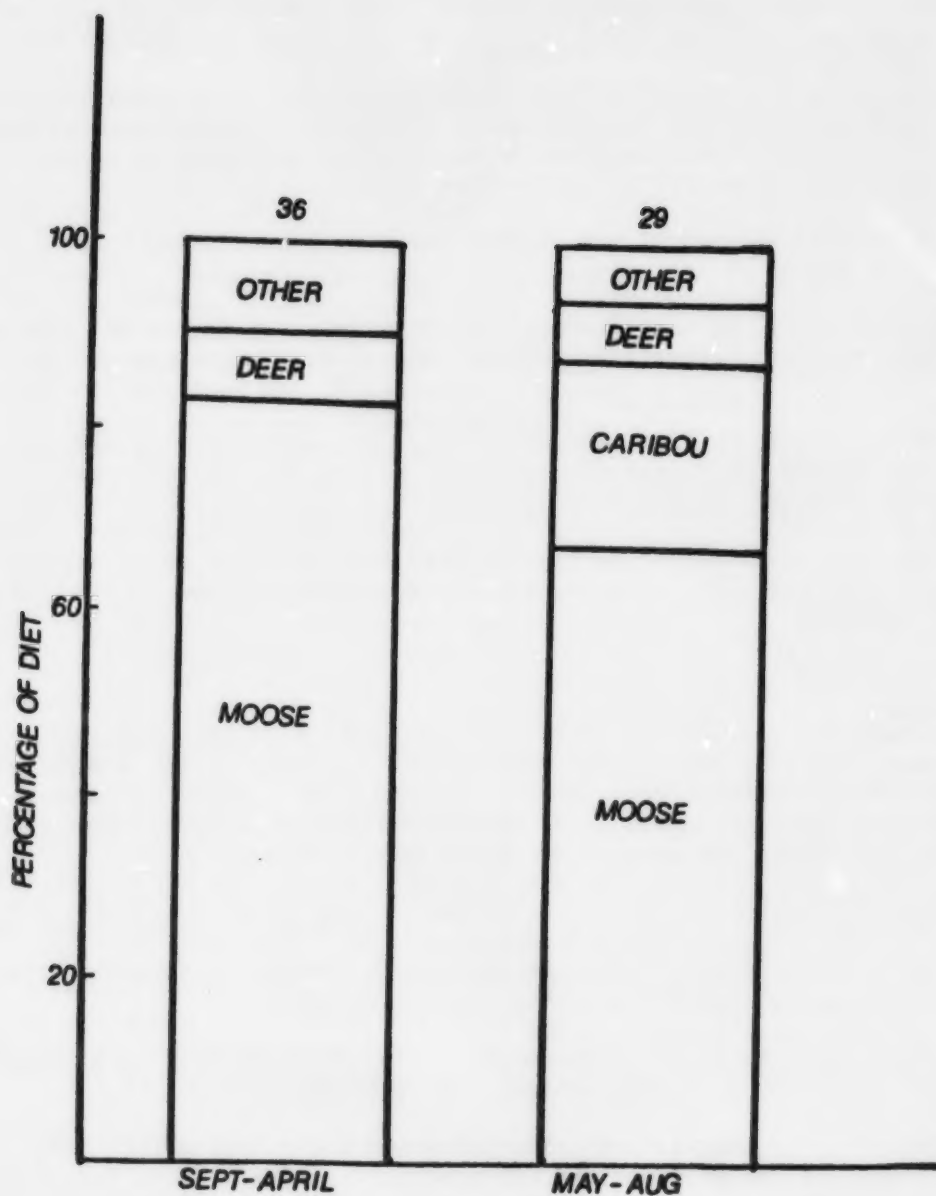


Figure 3. Food habits of wolves determined by scat analysis and corrected to account for differences in prey size.

Conclusions

1. Subalpine forests were the primary habitat of the caribou throughout the year. Low elevation cedar-hemlock forests were used by some of the caribou in early winter.
2. Pregnancy rate is close to 100%. Many calves die within a few days of birth. This mortality may be related to nutrition because the survival rate was higher in 1985 when there was an early green-up compared to 1984 when there was a late green-up in the calving area.
3. Calf survival throughout the summer was very low and was related to the presence of wolves in the area.
4. Adult mortality was high (about 30% annually). Accidents and predation were important adult mortality factors. Winter starvation did not cause any mortalities.
5. There was little contact between wolves and caribou during the winter months but during the summer, wolves were regularly found at high elevations in areas inhabited by caribou.
6. Wolves were sustained primarily by prey species other than caribou so it is likely that the wolf population would be maintained even if caribou numbers declined.

Acknowledgements

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3.4 THE CARIBOU AND WOLVES OF THE HORSERANCH RANGE OF NORTHEASTERN B.C.

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INTRODUCTION

The caribou (Rangifer tarandus) of northeastern British Columbia underwent a substantial decline during the 1970's. Numbers dropped from over 12,000 to less than 2,500 during that period (Bergerud 1978). While it was felt that insufficient restriction of hunting was a contributing factor for some herds in the decline, declines continued in the remaining substantial herds and low numbers did not increase in the depleted herds following severe curtailment of hunting (Elliott 1982). The primary indicator identified for the poor herd status was widespread low juvenile recruitment relative to adult mortality. Wolf (Canis lupus) predation was implicated as the most likely cause in this imbalance (Bergerud 1978, Elliott 1982).

In order to investigate the cause and effect relation between wolf numbers and caribou herd status, wolves were reduced in the range of one caribou herd (the Horseranch Range herd). Wolves were reduced for two periods, three years (1978-1980) and one year (1985), while the caribou herd was monitored. The investigations reported here cover the years 1978-1985.

STUDY AREA

The biogeophysical features of the Horseranch Range are described in some detail in Fenger et al. 1986. The range is located approximately 360 km west of Fort Nelson and is a sharply defined physiographic unit of the Dease Plateau. The range is 45 km long and 15 km wide. The orientation is approximately north-south with the western flank rising steeply from the valley floor (760 m) to a crest at 2,225 m. The eastern flank drops more gently to 1,050 m in the valley. The parent material includes both sedimentary and igneous rock types and the complex shows considerable glacial effects with cirque basins and morainal deposits. Typical of northern areas, the soils are acidic. The alpine and subalpine area is extensive.

The Horseranch Range caribou herd is isolated by over 75 km from any other significant caribou herds. This isolation was considered sufficient to exclude immigration/emigration effects. The caribou summer on the alpine/subalpine portion of the mountain.

In September and October they congregate on the alpine benches for the rut. In November they move off the range, down into the timbered lowlands where they remain for the winter, feeding upon terrestrial lichens and sedges. In March and April they move back to the alpine/subalpine of the range. Calving peaks in early June and at that time the calving females are on the snow free areas above the green line (emergent vegetation line) while the bulls and cows without calves are below the green line.

Moose (Alces alces) are present in densities typical of post-crash moose populations (approximately $0.3/\text{km}^2$; Elliott unpubl.). Small numbers of mountain goat (Oreamnos americanus) and mountain sheep (Ovis dalli) are also present. Wolves, black bears (Ursus americanus), and grizzly bear (Ursus arctos), are all found in the area although densities of the latter two are not known.

METHODS

Six sets of measurements were pertinent to this investigation. These measurements aimed at understanding the mechanics of the caribou population status plus the numbers of their main predator, the wolf. Specifically for the caribou, this study sought to define age specific recruitment and mortality rates.

In utero recruitment was estimated from necropsy of five adult females sampled in early June of 1978. Presence of a foetus or lactation (none was sampled when accompanied by a calf) was taken as evidence of pregnancy.

Neonatal recruitment (approximately two weeks) was estimated from five counts (1978-1982) in the third week of June. These counts involved intense contour searching from a helicopter of the range, both above and below timberline.

An autumn survey (mid-October) was used as the annual benchmark survey to identify total population and juvenile recruitment. At this time the caribou are almost exclusively in the alpine. As in June, the range was intensively searched with a helicopter along parallel contours. The range is snow covered at that time and in addition to direct sightings, all track sign was followed to identify the animals. This was particularly valuable for improving sightability of the few animals near treeline. Caribou were classified as cow, bull or calf.

Wolves were surveyed in late winter. The inventory method was to fly grids of likely wolf travel routes two to three days after a snowfall until fresh sign was encountered. Trails were then followed until either the wolves were seen or the tracks separated sufficiently to enable a count. When necessary, track counts were confirmed by landing and examining the sign in detail. Trail sign was also used to identify travel areas for each pack at that period. It appears likely (Peterson 1977; Mech 1970) that these represent annual home ranges and thus can be used as a measure of adult wolf levels beyond this period.

Reduction of wolf numbers was achieved by two procedures. Wolves were poisoned in 1978 and shot from a helicopter (by government personnel using conventional shotguns with SSG shot) during the other three years.

RESULTS

The in utero recruitment for caribou on the Horseranch Range was greater than the 86% found for seven North American herds (Bergerud 1980). Three of the five (60%) adult cows collected were still pregnant, while the remaining two were lactating although they no longer had an accompanying calf. Since the sampling excluded females still accompanied by early calves, this small sample is indicative of high in utero recruitment.

The calculation of neonatal recruitment requires an assumption. In the five years of June searching, only one calf was found below treeline even though adults were occasionally found there. It is concluded, therefore, that basically all neonates are above treeline. Visibility above treeline is good although the lack of complete snowcover (as in October) does exclude, in some areas, the option of following track sign. Furthermore, the area to search is reasonably small which reduces observer fatigue. Sightability for the alpine is expected to approach 100% and with similar observers and methodology each year should be fairly constant. Table 1 presents the number of cows in the spring (assumed the same as the fall). From this is calculated the number of calves per 100 cows.

Table 2 presents an index of spring snowpack for the area (termed winter severity in the table). This is calculated as the percent of the average (from 1966 to 1985) of the April 1 Dease Lake snowpack in water equivalent. Spring snowpack is considered to represent two features potentially important to the caribou. First, it is an index of the severity of the winter, since heavy snow and cold weather produce a greater snowpack. Second, it is an index of the proportion of the calving grounds still under snowdrifts in June. The first feature affects the nutritional balance of the caribou (for example in a hard winter, caribou need more food but it is more difficult to get). The second affects the predator vulnerability of the new caribou calves (the caribou calve on snow free areas and the more restricted these are the greater the relative density of calves and the less the predator search time between calves).

Table 3 presents the results of the autumn surveys. As with the June survey, sightability is an unknown. The predominant use of the open alpine and the close attention to track sign, however, means that this rate must be nearly 100%. This assumption is critical to the calculated rates. The 1981 survey was an exception and was excluded from calculations. Extended poor weather with low ceilings and high winds frustrated survey attempts. When weather conditions improved in later October much of the herd had left the alpine for the timbered winter range.

The four years of known calf:cow proportions allow the calculation of summer calf survival (Table 4). The 1980 value exceeds 100%. This may result from improved autumn sightability versus spring because of snow cover in the fall.

TABLE 1. Neonatal calf proportions for the Horseranch Range caribou, 1978 to 1982

<u>Year</u>	<u>Estimated Number of Cows*</u>	<u>Number of Calves Seen</u>	<u>Calves Per 100 Cows</u>
1978	182	80	44.0
1979	187	49	26.2
1980	183	47	25.7
1981	195.5	42	21.5
1982	208	21	10.1

* This is the number of cows seen in the fall total count except 1981 when it is calculated as the mean between 1980 and 1982 cow numbers.

TABLE 2. Winter severity

<u>Year</u>	<u>Severity Rating</u>
1977 - 1978	50
1978 - 1979	136
1979 - 1980	97
1980 - 1981	112
1981 - 1982	161
1982 - 1983	72
1983 - 1984	59
1984 - 1985	75

TABLE 3. October caribou census

<u>Year</u>	<u>Number Sighted</u>			<u>Total</u>
	<u>Cow</u>	<u>Bull</u>	<u>Calf</u>	
1978	182	37	44	263
1979	187	40	47	274
1980	183	78	50	311
1982	208	115	14	337
1983	178	57	15	250
1984	136	40	33	209
1985	140	63	71	274

TABLE 4. Calculated summer calf survival (as # calves in fall / # neonates).

<u>Year</u>	<u>% Survival</u>
1978	55
1979	94
1980	107
1982	64

TABLE 5. Hunter take (in September) from the Horseranch Range caribou

<u>Year</u>	<u>Take</u>
1978	4
1979	8
1980	4
1981	3
1982	15
1983	7
1984	6
1985	1

TABLE 6. Adult (> 4 months) natural mortality*

<u>Year</u>	<u>% Mortality</u>
1978 - 1979	11.0
1979 - 1980	3.6
1982 - 1983	28.2
1983 - 1984	27.2
1984 - 1985	2.4

* Adult natural mortality = $\frac{\text{No. caribou}(t) - [\text{no. adult caribou}(t+1) + \text{no. caribou harvested}(t+1)]}{\text{no. caribou}(t)}$

no. caribou(t)

TABLE 7. Annual rate of population growth*

<u>Year</u>	<u>% Growth</u>
1978 - 1979	+ 7.2
1979 - 1980	+15.0
1982 - 1983	-23.7
1983 - 1984	-14.0
1984 - 1985	+31.6

$$\begin{array}{l} * \% \text{ Growth} = \frac{\text{no. caribou}(t+1) + \text{no. caribou harvested}(t+1)}{\text{no. caribou}(t)} - 1 \quad *100 \end{array}$$

TABLE 8. Horseranch wolf numbers

<u>Year</u>	<u>Number</u>
1978	14
1979	4
1980	1
1981	8
1982	10
1983	15
1984	15
1985	0

The autumn counts for the seven years (Table 3) also allow five calculations of annual adult (in this case four months plus) natural mortality. Hunter take however must be excluded from the mortality to distinguish this variable. Table 5 presents hunter take during the term of investigation. Table 6 then presents the calculation of natural mortality.

The autumn counts also allow five calculations of annual rate of population growth. Hunter take can be excluded from the calculations to give growth in the absence of hunting. This value summarizes the effect of in utero recruitment, neonatal survival, summer survival and adult mortality. Table 7 presents these values.

Table 8 indicates the wolf levels for the Horseranch Range. Numbers largely reflect whether or not reduction was taking place.

DISCUSSION

Recruitment and mortality vary substantially for different ages and indeed the overall annual population growth reflects this with a range of -23.7% to +31.6%. Why is this variation occurring? Three hypotheses - with many variants - are generally considered to be possible in these situations: limitation by hunting, food or predators.

A comparison of Tables 5 and 7 quickly dismisses any possible control from hunting as the population changes bear no relation to hunter take. Population actually increased when sex ratios were most skewed and declined when least skewed (Table 3 and 7) indicating that the sex ratios resulted from the juvenile recruitment rather than the reverse.

A food limitation on the population would be expected to show itself in increased adult caribou mortality during, and a reduced calf crop following, a tough winter (the period of food shortage) and the converse for a mild winter. A comparison of the winter severity (Table 2) and adult mortality (Table 6) shows little correlation ($r = -0.4604$).

A comparison of winter severity with neonatal calf proportions (Table 1) shows a close correlation ($r = -0.9208$; Fig. 1; calves per 100 cows = -0.27 *snowpack rating +55). As noted in the results however, this does not necessarily relate to nutritional limitation as the snowpack also affects neonate vulnerability on the calving ground. An examination of several areas by Bergerud and Elliott (1986) suggests that the predation effect is the more significant. From the Horseranch data alone, an interpolation from the above equation for the neonatal calf proportions based on the snowpack index would predict a maximum 35 calves per 100 cows in the fall of 1985 assuming zero summer losses. However, Table 3 shows in that year, when there were no wolves on the range (Table 8), there were 51 calves per hundred cows in autumn. This gives added support to the predation link with the snowpack rather than a to forage effect.

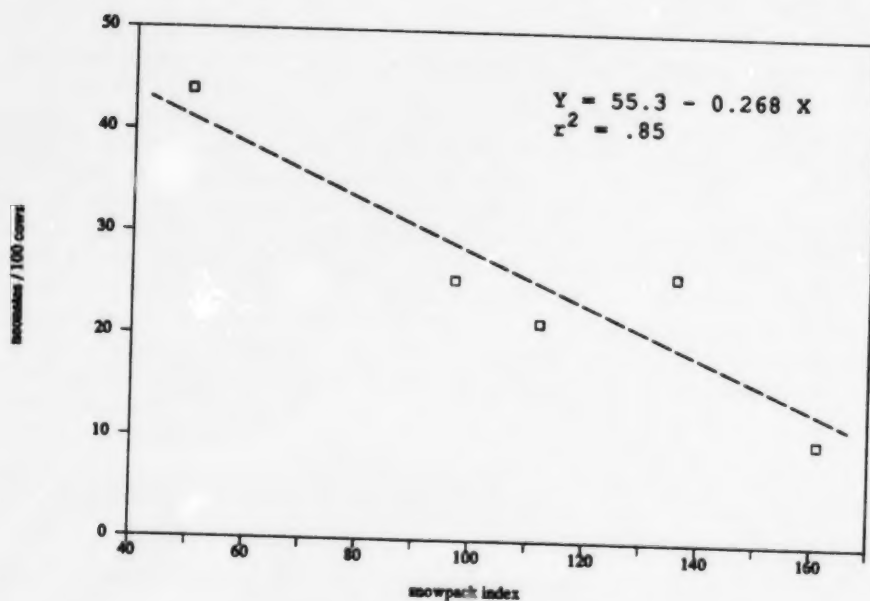


Figure 1. Neonatal survival.

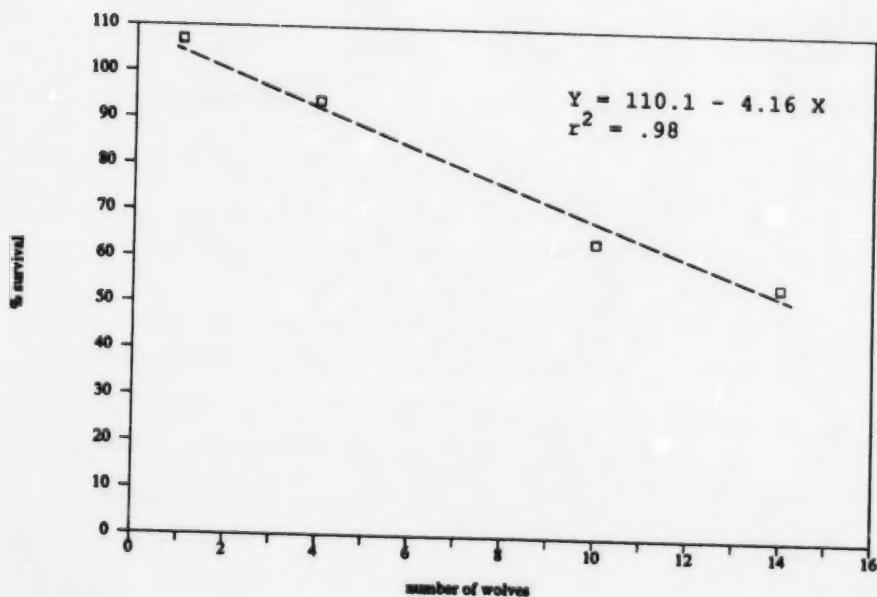


Figure 2. Oversummer calf survival.

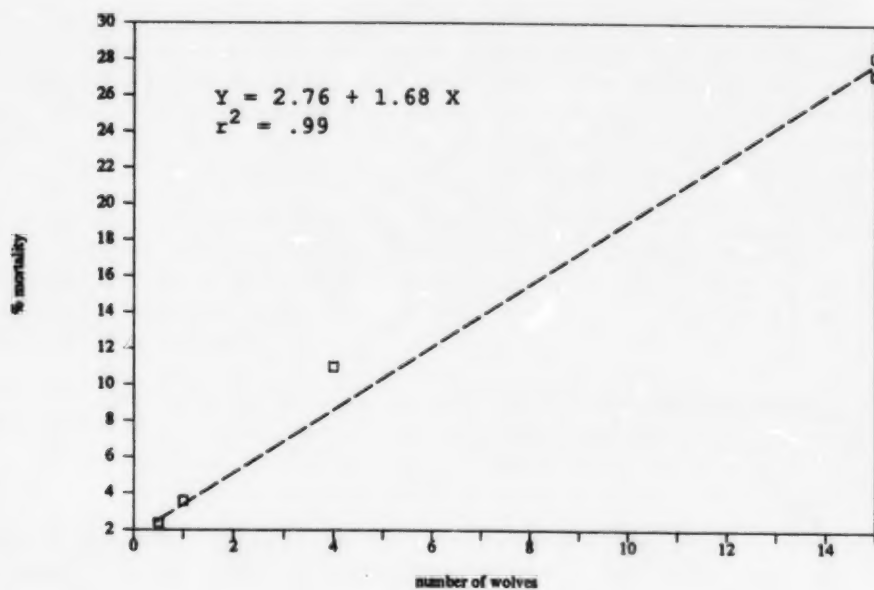


Figure 3. Annual adult mortality.

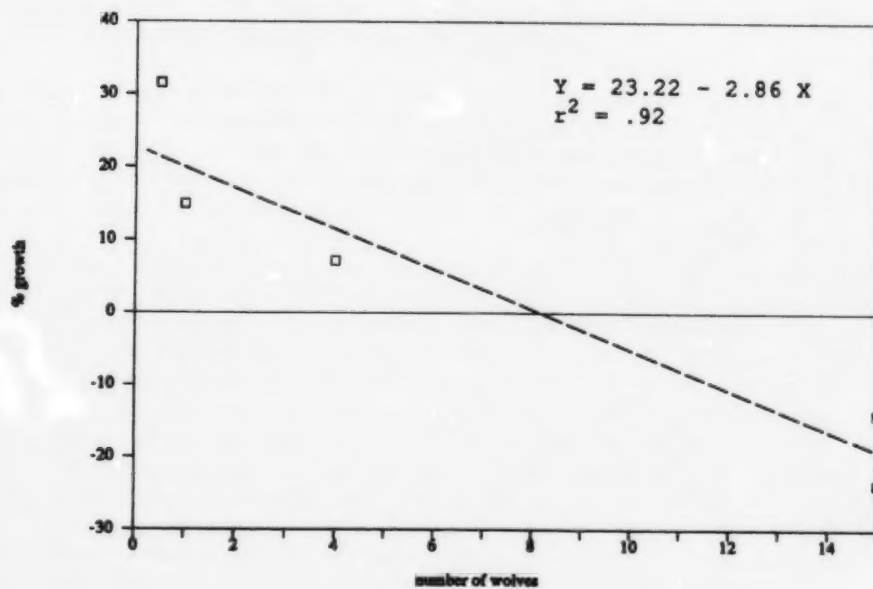


Figure 4. Annual population growth.

A predation limitation (by wolves) on the caribou population is well supported by the data. In utero recruitment is high. Also, as discussed, the neonatal recruitment is closely correlated with spring snowpacks which results from predation rate increasing as the snowpack concentrates the neonates (and their dams). Summer calf survival (Table 4) compared to wolf numbers (Table 8) shows a strong correlation ($r = -0.9912$; Fig. 2; summer calf survival = $-4.17 * \text{number of wolves} + 108.14$). Adult mortality (Table 6) compared to wolf numbers (Table 8) likewise shows a strong correlation ($r = 0.9970$; Fig. 3; % annual adult mortality = $1.67 * \text{wolf numbers} + 2.76$). Indeed, annual population growth rate (Table 7) and wolf numbers (Table 8) show a strong correlation ($r = -0.9566$; Fig. 4; % annual population growth = $-2.86 * \text{wolf numbers} + 23.2$). The caribou population not only appears limited by wolf predation but declines when wolves are unmanaged.

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3.5 SOME THOUGHTS ON DEVELOPING AND EVALUATING INVENTORY METHODS FOR CARIBOU

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INTRODUCTION

My first thought is that this topic can scarcely be touched in the 20 minutes allotted to it. To my frustration at that, add the effects of deprivation resulting from the fact that I have been called upon to prepare this and two other papers and travel 1800 km to present them with the hunting season still in progress and my deer tag still uncanceled and you will have at least a partial explanation of why I have decided not to let tact obstruct this delivery. I have been accused and, as will become apparent, am guilty, of having a "hang up" on the subject of inventory. I believe that it is often neglected and abused and may even be misunderstood. My approach here will be to affirm its importance, to describe some general aspects of inventory development and evaluation, and briefly outline some pertinent findings from my studies in northern British Columbia.

THE ROLE OF INVENTORY

I will start at the beginning in case someone here doesn't know or has forgotten what inventory is all about. My use of the term refers to the process of gathering field data on animal distribution, numbers or population composition. I emphasize the word "field" in the previous sentence, to distinguish the real thing from planimetric inventory, wherein a manager multiplies an assumed animal density by a measured area on a map to determine numbers. Inventory, like kite-flying, is an outdoor sport.

Wildlife ecology is considered to be science and wildlife management is science applied. If it is science we are involved in, then the foundation for our activities is fact, and many of the facts we need are generated by inventory. Management is largely a set of actions which responds to and attempts to promote changes in populations; therefore one of the most important ingredients in the management process has to be the information that enables detection and recognition of those changes. Without that information, how can we either ascertain when management should be applied or determine whether it has been successful?

I consider that each management action is ideally a kind of scientific experiment, beginning with a series of observations (inventory to identify management needs) which suggest a treatment/manipulation (management), followed by another series of observations to see what happened (inventory to monitor management results) (item A, Figure 1). In practice, of course, an inventory can serve both to assess the effects of past management and to indicate the need for and nature of actions to follow. It is my position, however, that management actions should be preceded by facts that justify them and followed

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- | | | | | |
|----|--------------------------------------|------------|-------|--|
| A) | INVENTORY TO
IDENTIFY MGMT. NEEDS | ---> MGMT. | --- | INVENTORY TO
MONITOR MGMT.
RESULTS |
| B) | INV. TO
IDENT. NEEDS | --- | MGMT. | --- |
| C) | X | --- | MGMT. | --- |
| D) | X | --- | MGMT. | --- |
-

X = NO INVENTORY

FIGURE 1. Relationship of inventory to management

by acquisition of facts to evaluate them. Items B-D in Figure 1 are representations of shortcuts I have witnessed, including the absence of specific follow-up observations (common), attempts to justify management actions after they have been instituted (Watergate inventory), and management with no inventory.

The missing facts on both sides of management are often replaced by convictions (sometimes referred to as "our best professional judgment" in letters to the complaining public). But, convictions are the stuff of religion, not science, and differences in convictions have often led to war. I suggest that at least part of the musical chairs nature of the Ministry of Environment cabinet portfolio is due to failure of that ministry to do its homework in the facts-from-inventory arena.

QUALITY OF INVENTORY

The foregoing paragraphs have dealt with the function of inventory and have considered deficiencies in the quantity of effort applied to that activity. Even given agreement that it is important and necessary, problems of quality remain. I have heard managers attempt to justify inventory-deficient programs with the argument that "management information does not have to be as good as that for research". That argument is spurious in that it avoids the question of just how good either kind of information has to be. I agree that research may require a higher degree of accuracy than management, just as long distance shooting may require a rifle rather than a handgun. However, whether armed with research or management level data, rifle or pistol, the objective should be to be on target. The trick is in knowing and acknowledging the limitations of one's weapon.

In a recent review of the status of caribou populations throughout southern and central B.C., Stevenson and Hatler (1985) lamented the "fragmentary, inconsistent and generally inconclusive nature of most of the information". Although difficulty in interpreting scattered historic data was not surprising, we noted that even "more recent data, having been produced by a variety of methods on an irregular basis are difficult to compare". In a previous report (Hatler 1983), I presented evidence that recent research data were apparently not even good enough for management, and concluded that the lack of a reliable and consistently applied inventory system has been a major impediment to our understanding of woodland caribou populations. That was more confirmation than revelation. The provincial management plan for caribou (BC Ministry of Environment 1979) had previously stated that "...the development of new and standardized inventory techniques is required". In short, we haven't really known how to do it.

Foresters in the crowd may be startled by that, so it is important for them to consider that the subjects of their own inventories can not move. Caribou do not stand up to be counted; indeed, they tend to treat inventory teams as they would predators, making every effort to avoid them. Furthermore, at

survey time the animals may be located where we expect them and they may not. They, and other wildlife species, like the muskrats studied by Errington (1963), "...have nothing to prove, disprove, rationalize, or explain, and, being to some extent free agents, they do not necessarily have to do things one way if another way will suffice. Their job is living and they work at it full time."

And this leads to imagery I have used before, and, with apologies to those of you who were exposed to it last time, I use it again. On the front of a movie theatre you will usually find a poster bearing three or four photographs developed from single frames out of the thousands that constitute the movie. Those single-frame photographs have to be carefully selected if they are to impart to you, the potential moviegoer, a representative view of what the movie is about. I argue that our inventories are equivalent to those sample frames -- mere glimpses within the full-time lives, 365 days a year, of the animals, but glimpses we hope will tell us what their lives are about.

As with the Spatsizi caribou described in my previous paper a few hours ago (this volume), populations of wildlife may range over hundreds of square kilometres in patterns which are reasonably predictable by season. However, day-to-day variation within a season is common. The chore of selecting times and places which will provide representative and reliably comparable results is not an easy matter.

Presently, caribou counts in British Columbia are conducted at different times in different places. In some cases, survey timing has been a matter of political necessity, as occasioned by some management crisis, and sometimes it has been a matter of convenience, often at the end of the fiscal year. In most cases, however, the favoured timing reflects local perceptions of when the animals may be most readily contacted: in southeastern B.C. (Wells Gray Park), surveys are scheduled to catch caribou when they are using high elevation snowpatches in July; to the west (Cariboo Region) the highest counts have also been obtained in summer, but on upland calving areas in June or early July; and in one area of north central B.C. (Telkwa Range), the best counts have been recorded in late winter-early spring (Stevenson and Hatler 1985). Following the lead of Bergerud (1978), most caribou in the northern half of the province are censused during the full rut period, when concentrations of animals may predictably be found in open areas above timberline.

INVENTORY DEVELOPMENT AND EVALUATION

As used in relation to survey activities in this paper, "development" refers to aspects of the specific methods and timing of surveys, while "evaluation" refers to consideration of their relative success in providing population estimates which approach the true population figures. Most observers become at least informally engaged in both development and evaluation whenever they conduct a census. Evaluation involves such qualitative statements as "we believe we saw a large proportion of the animals", or maybe

apparently more precise, for example, "we believe we saw 85% of the animals". Development at that level often takes the form of statements such as "it was too soon after the snowstorm" or resolutions such as "I'll never use that pilot again". The relationship between evaluation and development in the above discussion is obvious, the former affirming whether or not a particular survey went well, and the latter describing factors thought to have influenced observed results.

DEVELOPMENT AND EVALUATION ACTIVITIES IN NORTHERN B.C.

As I have indicated previously, one of the primary objectives of our telemetry studies in the Spatsizi Wilderness Park area has been consideration of inventory, and I will be preparing a major report on the subject over the next several months. In the time remaining here I will describe the basic methods and rationale of the Spatsizi inventory studies and will briefly refer to some of the findings.

Inventory Development

The primary activity has simply been assessing, through radiotracking, seasonal animal distribution patterns in terrain and cover where observation and representative counting would be possible. In effect, for every radio location the question can be asked, "If I were conducting a census at this moment, what would be the chances of locating, counting, and classifying this particular animal or group of animals?" Figure 2, which summarizes elevation data for approximately 700 radio locations of females over 4 complete annual cycles, exemplifies the kind of assessment which can be made. As shown, in 3 of 4 years most animals were found below timberline from December through May, thus they were largely unavailable for counts during that period. Two points should be made about the exceptional case, in the winter of 1980-81. The observed pattern in that year was due to an unusual pattern of snow accumulation but because that was the first year of study, with no other information for reference, it was tentatively concluded that the animals winter in alpine situations. One-shot inventories such as those normally undertaken for habitat protection or impact evaluation studies would have produced a completely erroneous view of the value of lowland forests in the area if conducted in that winter. The second point is that despite the fact that the winter period is clearly not a good time for regular annual surveys, the 1980-81 situation presented the best opportunity for a near total count in the area that I have observed in over 5 years of regular visits there.

During the remainder of the year, as shown in Figure 2, the animals have been mostly above timberline, with the highest frequency in actual alpine habitat during the summer. Though somewhat lower in the fall, the animals have nevertheless remained mostly above timberline at that time, a result which confirms its potential for surveys. Other factors which I have been analyzing in relation to the inventory potential of observed time periods include the frequency of occurrences in broad habitat types, general distribution and dispersion, group size, and snow cover. Consideration of habitats is primarily

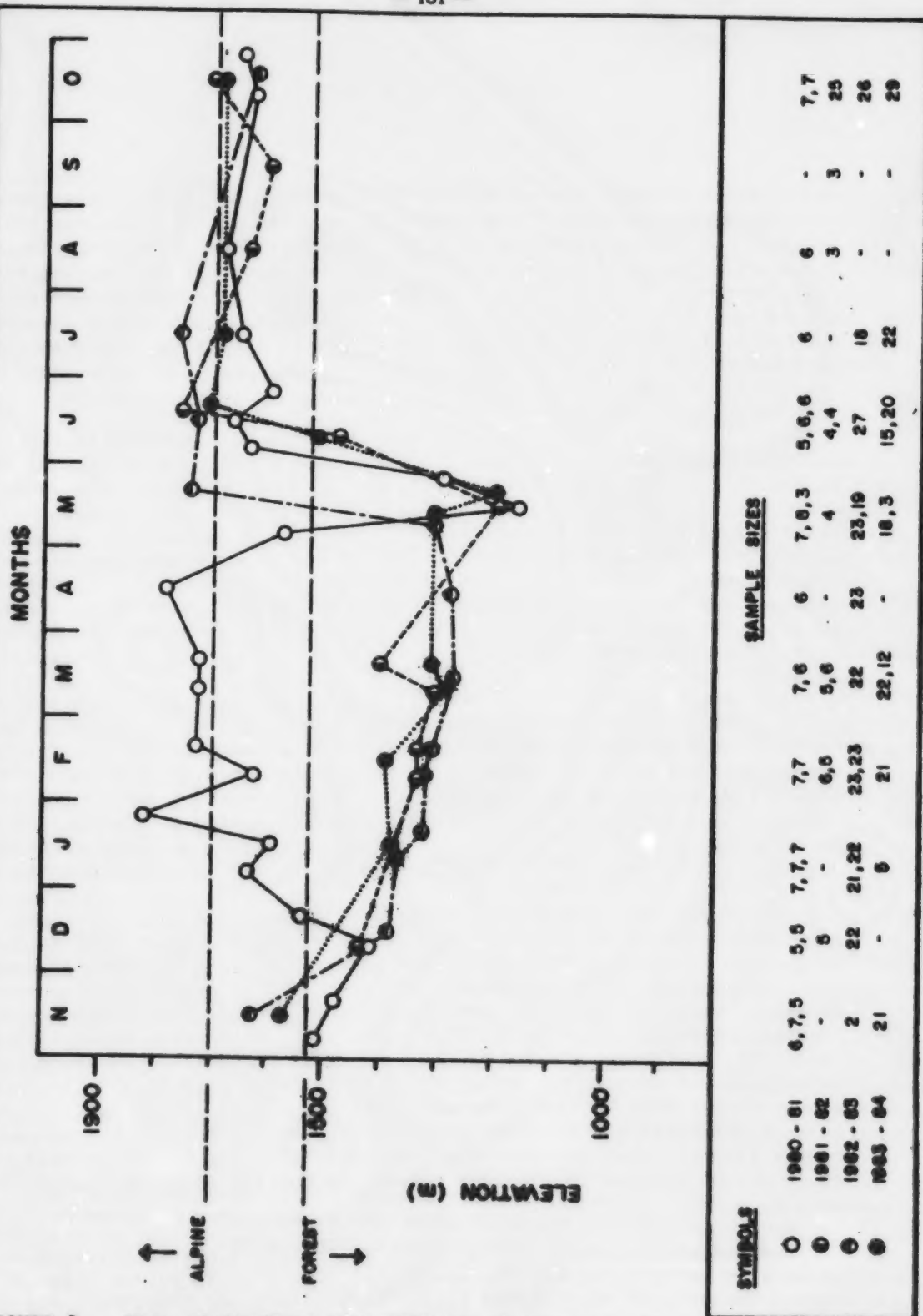


FIGURE 2. Mean altitudinal distribution of female caribou on 59 tracking flights in the Spatsizi Wilderness Park area, British Columbia, 1980-1984.

on the basis of relative visibility of animals in different cover types. For example, at the subalpine level commonly occupied in the fall, the animals may be in low deciduous shrub cover or in patches of dense subalpine fir. The degree of dispersion has implications for the amount of flying that might be required to complete a survey. It appears that the largest groups may be encountered at rut time, a fact with both positive and negative implications for inventory, since large groups are easier to locate but are more difficult to classify.

Inventory Evaluation

Caughley (1977) noted that "to determine how well a sampling system and analysis copes with a real population, we must know the exact number of animals in that population. And to determine why it copes well or badly we must know where each animal was standing at the time of survey". He states further that "this information is never available". However, with a sample of instrumented animals constituting the population, it is possible to know how many are present and to come fairly close to knowing the location of each during a survey. That has been the basis for my evaluation studies in the Spatsizi area. Following is a summary of some considerations and results in evaluation of a rut census in October 1984.

The census evaluation had several components. The first, termed "sightability", involved the question of whether all of the animals one hoped to count were seen, and the second, termed "representativeness", focused on the question of whether the sample of animals counted had the same sex and age composition as the entire "population". Other important considerations included the problem of establishing population status and trend from the sample counted, and the question of survey efficiency in terms of costs, but only aspects of sightability and representativeness will be presented here.

- Sightability - There are two primary considerations, as follows: 1) the proportion of animals present which are potentially visible, and 2) the proportion of those visible which are seen. The first is affected primarily by the distribution of the animals, i.e., whether they are in open upland habitats or are in cover in which they may be at least temporarily hidden. The October surveys are largely limited to open shrub and alpine areas above 1525 m (5000 ft), on the assumption that most animals concentrate in those habitats during the rut period. In 1984, 14 of 19 collared animals (73.7%) in the immediate vicinity of the three main rutting uplands in the Spatsizi Park area were in locations and habitats in which they were likely to be seen during a census flight. That is, more than one quarter of the marked animals present could not be counted for reasons beyond the control of those conducting the census.

The second component of sightability, as listed above, involved only the 14 animals actually occupying the designated open-habitat survey areas at survey time. The factors which could potentially affect the observers' ability to count such animals include cryptic coloration in some lighting and background

situations, attempts in unfavourable weather such as fog or snow, and various "human error" factors such as experience, concentration, eyesight, navigational abilities and fatigue. The important point here is that observers do have some control over that aspect of sightability. The 1984 results demonstrated that a competent crew, exercising good judgment, can actually count most of the animals occupying the expected areas -- in that case 13 of 14 (92.9%) of the marked animals being seen. The primary variable in this case appeared to be intensity of coverage. In 1984, poor visibility conditions resulting from patchy snow cover was compensated for by increasing census flight time over that normally used for rut surveys in the area.

The above result was consistent with those from previous years, and I concluded that the second component of sightability was less important than the first in that area. I suggested that future evaluations could focus solely on the distribution of animals, in which case high sightability is implied and sample representativeness becomes a more important issue.

- Representativeness - One of the major objectives in the fall caribou census work is to obtain data on population composition, with particular reference to sex ratio and proportion of calves. Observation of our collared animals in past years has indicated that the important classes (bulls and cow/calf pairs) may be under-represented in fall counts on the major rutting areas. The 1984 results provided further support for that view, particularly in the case of calves, and only results for that class will be given here.

Table 1 summarizes the 1984 maternal and location histories of 22 collared female caribou in the Spatsizi area, as recorded during field studies in June, July, October and November. The basic location references are three upland areas on which the park rut surveys are conducted. As shown, during calving most animals were located away from those areas. As the summer progressed, they gradually moved back to them, but the tendency was less for females with calves than for those without. Of 8 females known or suspected to have had calves with them at survey time in October, 4 (50%) were not in the immediate vicinity of any of the survey areas, and only 3 (37.5%) were occupying habitats in which they could be seen. On the other hand, of 14 females known or suspected to have been without calves during the October period, 12 (85.7%) were contacted in the general survey areas and at least 9 (64.3%) were in the upland habitats observed on survey day. Two others were believed to have been in upland habitats a few days earlier, but had moved down into the forest by survey day, and the remaining animal apparently stayed in a timbered lowland area throughout the study period.

In my earlier paper (this volume), I summarized the pattern of seasonal distribution and movements in the Spatsizi area. In general, it showed a tendency for the animals, especially females, to make their farthest penetrations to south and west in spring, during the calving period, followed by a general northward movement which is essentially complete by early winter. It appears that throughout the summer and fall, females with calves are less

Table 1. Distribution of collared female caribou relative to October rut survey areas, as recorded during June - November 1984 tracking studies, Spatsizi Wilderness Park and vicinity.

Dates	No. Caribou ^b	Areas ^a				All
		Other	CM/M	Tomias	Edoz.	
<u>12-16 June</u>						
With Calves	13	0	0	0	13	
Without	5	2	0	0	7	
Not Known ^c	2	0	0	0	2	
Totals	20	2	0	0	22	
<u>20-21 July</u>						
With Calves	7	0	0	1	8	
Without	6	4	1	0	11	
Not Known ^c	3	0	0	0	3	
Totals	16	4	1	1	22	
<u>5-9 October</u>						
With Calves	3	2	1	1	7	
Without	1	9	3	0	13	
Not Known ^c	2	0	0	0	2	
Totals	6	11	4	1	22	
<u>26-27 November</u>						
With Calves	2	5	0	0	7	
Without	2	12	0	0	14	
Not Known ^c	1	0	0	0	1	
Totals	5	17	0	0	22	

^aOther = areas away from those usually surveyed during fall rut counts; CM/M = Caribou Mountain and Marion areas; Edoz. = Edozadelly Mountain. Tallies for the rut count areas include animals seen in adjacent lowlands within the respective wildlife zones.

^bMaternal status by observation of calves and/or the following assumptions: females seen with calves in time periods "a" and "c" also had them in "b"; females seen without calves in June and July did not have them in October or November; the November status is assumed the same as that in October unless known otherwise; Caribou A01, with a non-functioning transmitter, is not included in these calculations because her June location and status are not known.

^cThe category "not known" refers to animals which were not seen on a particular flight, and whose status could not be inferred from observations on other flights (see footnote b).

inclined to make extensive movements than are those without. Those with calves in areas near the survey areas are likely to attend them in October, while successful females in more remote areas may not. Meanwhile, females without calves begin to appear in the survey areas by July, often from some distance, and they generally get to the northernmost portions of their range (e.g., Caribou Mountain) earlier than do those with calves. Past surveys have generally shown higher calf ratios at Edozadelly than at Caribou Mountain. Bergerud (pers. comm.) has postulated that different predator regimes in different parts of the park area are responsible, but it now seems that the difference can be partially explained by this differential movement pattern of successful vs. unsuccessful mothers, though Tomias Mt. (in an intermediate position) has the lowest counts.

As shown in Table 1, 3 of the 8 known or suspected successful mothers were still in outlying areas in late November. However, one of those was already in the lower Stikine drainage area (mountains near the Pitman River), and one was just south of the Spatsizi River, 50 km north of her July location, i.e., apparently enroute to the Caribou Mountain area. Further, all of the other successful females, including the one which had been on Tomias Mountain and the one which had been on Edozadelly during the October survey, had moved north and were in the Caribou Mountain/Marion uplands in November.

The important implication of the above result, which also occurred in 1983, is that an intensive survey at Caribou Mountain in mid- to late November may provide less biased and more cost-effective data on recruitment than that obtained in the usual October surveys. Whether a November survey would produce better or poorer sex ratio data is not yet known, but additional advantages of that time period include a more uniform snow cover to enhance sightability and tracking, possibly smaller group sizes, and increased potential for significant incidental observations of other ungulates in the area, especially moose and mountain sheep.

SUMMARY

I have provided some thoughts on the role and importance of inventory, have argued that better inventory is needed, have discussed aspects of developing and evaluating inventory methods, and have provided some examples from a continuing telemetry study of caribou in the Spatsizi Wilderness Park area. An important finding is that observed seasonal movement patterns of caribou in that area are such that the standard rut survey appears to be too early to fully document recruitment, the major objective of those surveys. Based on aspects of seasonal life history documented during regular radio locations of up to 30 animals over a four year period, I have suggested that an alternative census timing over a smaller than usual survey area be explored.

EPILOGUE

I confess to more than a little idealism in my enthusiasm for good inventory, but I am not utopian in that regard. Recalling the earlier quote from Errington (1963) in regard to the essentially free agent status of animals, I am fully aware that complete predictability of timing/location/behaviour will never be possible, and managers will never have the luxury of perfect information to work with. Furthermore, it is highly unlikely that budgets will ever allow the amount of inventory that would ideally be required.

My firm position, however, is that we can and must do better than we have been, and I encourage other researchers with instrumented animals to be on the lookout for information to enhance our capabilities.

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3.6 MANAGEMENT OF CARIBOU IN SPATSIZI PLATEAU WILDERNESS PARK

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ABSTRACT

Spatsizi Plateau Wilderness Provincial park contains about 15% of the total caribou population within British Columbia, and provides about 6% of the provincial caribou harvest. Concern for the status of the population led to a management program which determined harvest rates directly from intensive inventory data. The objectives of the program were to provide harvests which were not detrimental to the population, and to demonstrate competent management to the public.

The inventory data suggested that caribou recruitment, proportion of bulls, and population size decreased before 1979, likely because of predation by wolves and grizzly bears. Recruitment and sex-ratio then improved and the population stabilized through 1985. However, recruitment and sex-ratio were still below the potential for caribou and there was no evidence of a population increase. Analysis of the population data indicated that harvests should not exceed 1.5% of total numbers when most animals taken were bulls 4 years or older. This harvest rate was about one-half of the calculated net annual recruitment into the harvested sex-age class and therefore allowed for an increased proportion of bulls in the population.

Evaluation of the inventory data indicated that caribou surveys were very variable, that annual counts from one part of the range did not accurately represent population trends, and that all caribou groups must be classified to minimize bias in the population ratios. The annual range of the population included a wider area than the park, and management should be based on the population range instead of on administrative units to provide effective protection and use of the resource.

ACKNOWLEDGEMENTS

Many people assisted in the caribou inventory over the years, including G. Hazelwood, D. Hatler, B.V. Drimmelen, D. Eastman, I. Hatter, M. Sather, T. Bergerud, W. MacGregor, R. Marshall, K. Fujino, D. Carmichael, R. Page, T.O. Jones, R. Collingwood and T. Brooks. R. Collingwood has provided generous logistical support. D. Hatler and T. Bergerud have provided additional information and substantial personal knowledge about caribou.

INTRODUCTION

Spatsizi Plateau Wilderness Provincial Park is located in the Cassiar mountains in northwestern British Columbia and incorporates most of the headwaters of the Stikine River drainage (Figure 1). The park is centered on 57.5° Lat. and 128.5° Long., and extends over approximately 660,000 ha.

Spatsizi Park presently contains about 15% of the total caribou (Rangifer tarandus caribou) population within British Columbia, and provides an average of 6% of the provincial caribou harvest. The caribou have been managed intensively since 1977 because of concern for the population and because of substantial public interest in wildlife management within the park. The B.C. Parks Division has conducted most of the management because of the responsibility provided by the Park Act.

Hunting within Spatsizi park is tightly regulated. The number of B.C. residents hunting caribou is controlled by a Limited Entry Hunting (LEH) draw system. The harvest by non-residents is controlled by a quota system. The LEH and quota controls have been in place since 1977 and are administered by the Wildlife Branch. The harvests are adjusted annually in response to changes in the inventory information and harvest data.

MANAGEMENT STRATEGY

Caribou inventory before 1979 indicated that calf recruitment was low and that the sex-ratio was close to the 20 bull:100 cow level where reductions in breeding success may occur (Bergerud pers. comm.). Inventory in 1977 had shown that at least 82% of the cows produced calves and therefore there were no current concerns for pregnancy rates (Bergerud and Butler 1978). However, since the sex-ratio was unbalanced and could be further reduced by excessive harvest, and since there was considerable public interest in the population, the overall management strategy was to:

- a) increase public support for the management program by demonstrating technically competent management;
- b) conduct annual monitoring of the sex-ratio and recruitment in the population, and allow hunting so long as the sex-ratio was greater than 20 bulls:100 cows, and calf recruitment was at least 10% of total numbers;
- c) use the inventory data to calculate a harvest rate that would allow for an increase in the sex-ratio, and adjust as warranted by new information;
- d) support research studies which would improve the management knowledge.

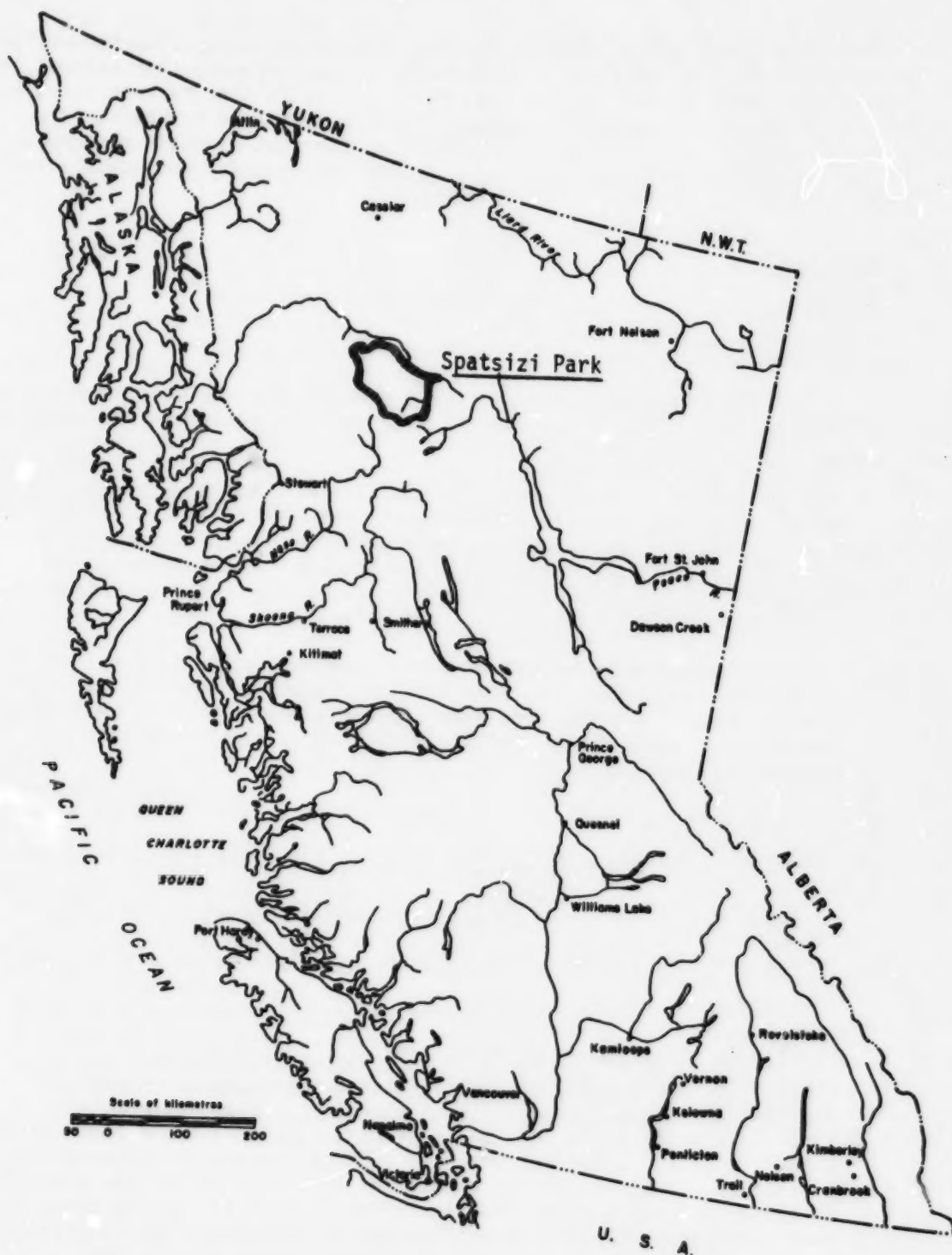


Figure 1. Location of Spatsizi Plateau Wilderness Park in Northwestern British Columbia

The caribou management program followed the Parks policy that the welfare of wildlife must be the first consideration in any activity that affects the population. With respect to hunting, Parks policy is that harvest rates must be conservative in relation to maximum possible sustained harvests. The program was also consistent with the Parks policy that wildlife management within provincial parks must generally follow the policies and administrative procedures of the Ministry of Environment.

METHODS

1. Caribou inventory

Caribou were intensively surveyed from jet helicopters annually from 1976 through 1985. All inventory data used for management purposes were collected during the fall pre-rutting period, when caribou tended to aggregate on alpine habitats. Most surveys were conducted in the first week in October of each year. In Spatsizi Park the 3 major rutting areas were the Caribou Mountain/Marion zones (referred to as Caribou Mtn.), the Tomias zone, and the Edozadelly zone. The Caribou Mtn. zone was surveyed annually (except for 1978), and the other zones were surveyed approximately bi-annually. In some years, caribou were also counted in zones immediately to the east of the park.

Most surveys were conducted very intensively with the ideal objective of counting every caribou above treeline (approx. 1500m elev.) in the area surveyed. Flight-lines were generally spaced at 1 - 3km intervals, depending on snow cover. Caribou were usually classified into the following categories:

- large bull : large, complex antlers, usually with palmated brow tine
- medium bull: moderate antlers, usually with simple brow tine
- small bull : could not be distinguished from cows by antlers
- cow : identified by presence of vulval patch
- calf : smaller than adults, antlers in velvet

Prior to 1980 a proportion of the observed caribou were classified. After 1980, it was considered necessary to completely classify all groups, regardless of size, but occasionally it was impossible to classify very large groups, or groups found immediately below treeline. In recent years 70-100% of observed caribou were classified. Analysis of the classified data showed that the proportion of calves and bulls decreased significantly with increasing group size, confirming that complete classification of all groups was essential to minimize bias in the calculated population ratios (Ramey 1984).

In 1982 and 1983 the variability of the total counts was assessed by conducting several replicate surveys over a two week period in late September - early October.

In addition to the annual inventory, additional information was obtained from caribou research studies conducted in Spatsizi Park (Bergerud and Butler 1978; Hatler 1985; Page 1985).

2. Caribou harvests

After 1978 only bull caribou were legal game within British Columbia. Annual harvests from Spatsizi Park were determined from guide-outfitter reports to the Parks Division and the Wildlife Branch, and from complete harvest records maintained by the Wildlife Branch. The age of the harvested caribou and the residency status of successful hunters were obtained from the provincial harvest records.

3. Predator populations

Systematic surveys of wolves (Canis lupus) and grizzly bears (Ursus arctos) were not conducted in Spatsizi Park. The presence or absence of predators in the survey areas was determined from incidental sightings during the caribou surveys, and during wildlife surveys conducted for other purposes.

RESULTS

1. Caribou inventory

Replicated surveys in late September - early October 1982 found that caribou numbers in the Edozadelly zone increased to October 4 and then dropped over 2 days (Figure 2). In 1983, caribou numbers in the Edozadelly and Caribou Mtn. zones were generally high over the sample period, but were depressed on October 1, likely in response to poor weather (Figure 2). A survey on November 22 on Caribou Mtn. found similar numbers to the survey on October 9. However, experience suggested that few caribou were on the Edozadelly and Tomias rutting areas after mid-October. The replicated surveys clearly showed that observed caribou numbers varied substantially over the late September - early October period, and that the temporal pattern of variation varied between years. Consequently, single samples could not provide a precise population index, and observed trends in total caribou numbers must be corroborated by additional data.

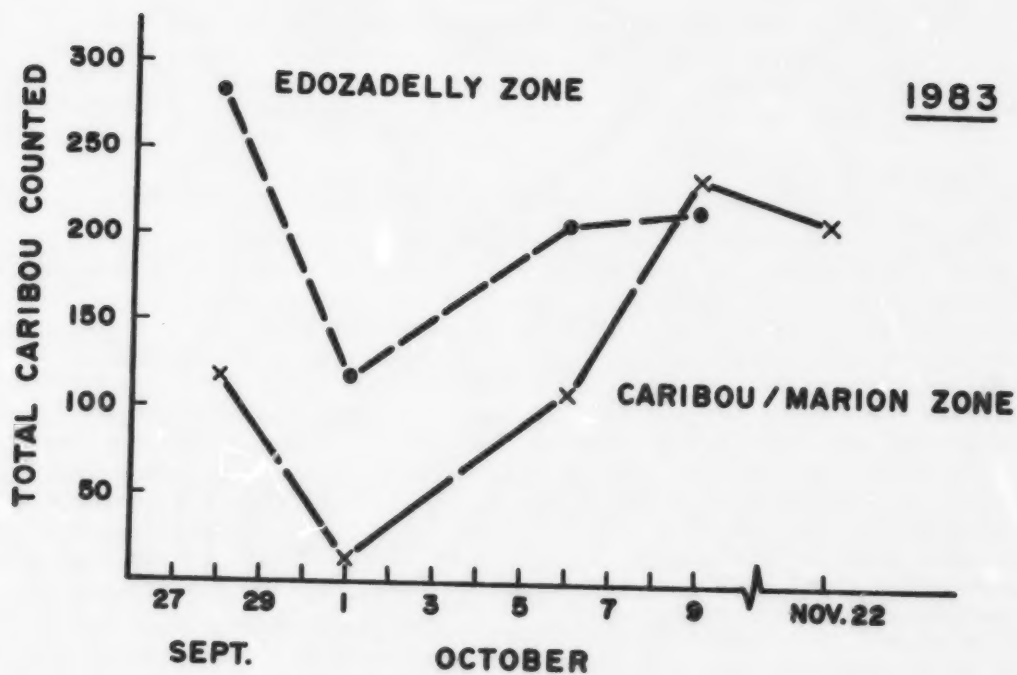
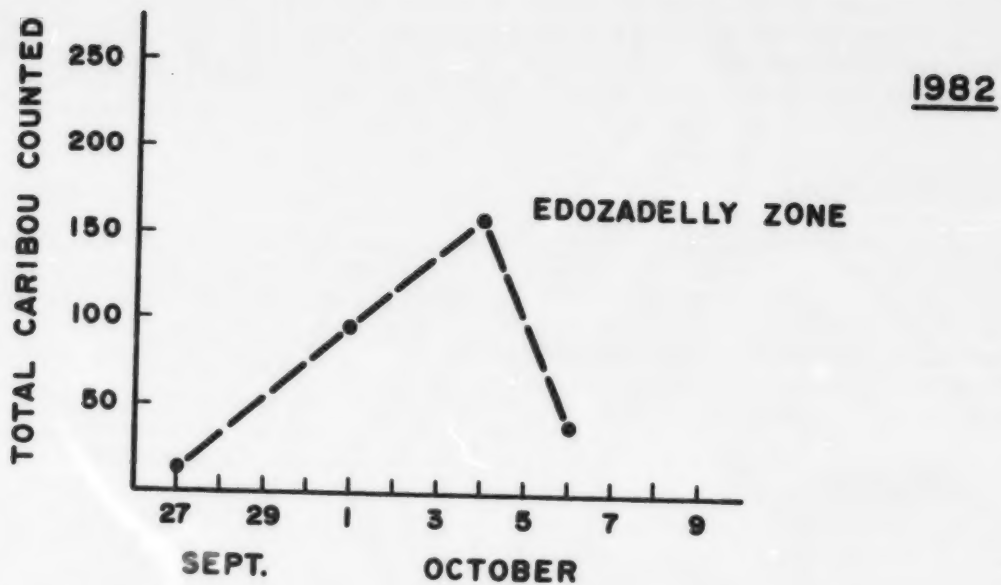


Figure 2. Temporal Variation in Total Caribou Counts in the Pre-rut period

2. Predator populations

The incidental sightings of wolves and grizzly bears indicated that both species were relatively common in the survey areas from 1976 through 1985. Wolves were very abundant in 1976, and a pack of 29 was observed in the Tomias zone. It was suspected that wolf populations declined during the 1976 - 1985 period, but at least two packs of about 8 - 15 wolves each were present in the rutting areas annually from 1980 through 1985. Specific information on grizzly bear numbers was lacking, but it was believed that the population in the park was relatively stable throughout the study period.

3. Caribou population trends

The observed trends in the total counts are shown in Figure 3. The total counts from all zones, including those to the east of the park, were higher in 1976 and 1977 than in 1980 and 1982. The total count in the three park zones declined between 1977 and 1980, and then remained stable through 1984. The total number of caribou counted in the Caribou Mtn. zone was stable from 1976 through 1985.

The observed trends in the population demographics are shown in Figure 4. The adult sex-ratio (bulls:100 cows), and calf recruitment to October (calves:100 cows) were both low before 1978, and then increased through 1985. Reductions in sex-ratio and recruitment in 1982 were likely related to the unusually severe winter of 1981-82. More intensive studies by Bergerud and Butler (1978) and Page (1985) found high calf mortality and unbalanced sex-ratios, and were consistent with the results of the inventory.

Although the observed recruitment and sex-ratios improved up to 1985, they were still below the potential for caribou. Recruitment ranged between 14 - 27 calves:100 cows from 1981 through 1985, or 10 - 16% of the total caribou sampled, just above the 10% calves normally needed to maintain a stable population (Bergerud and Butler 1978). Similarly, the recent sex-ratios were below the 1 male:2 females normal for caribou (Bergerud and Butler 1978). The low recruitment was likely caused by calf mortality, and the low bulls:100 cows likely resulted from greater mortality of males than females in all age groups.

The age-class distribution of caribou harvested since 1978 is shown below:

Age structure of caribou harvested from Spatsizi Park

	<u>% of harvested caribou in age class</u>				
	1 - 3 year	4 - 6 year	7 - 9 year	10 year plus	
1978-81	3%	33%	50%	14%	n = 64
1982-84	4%	58%	32%	6%	n = 50

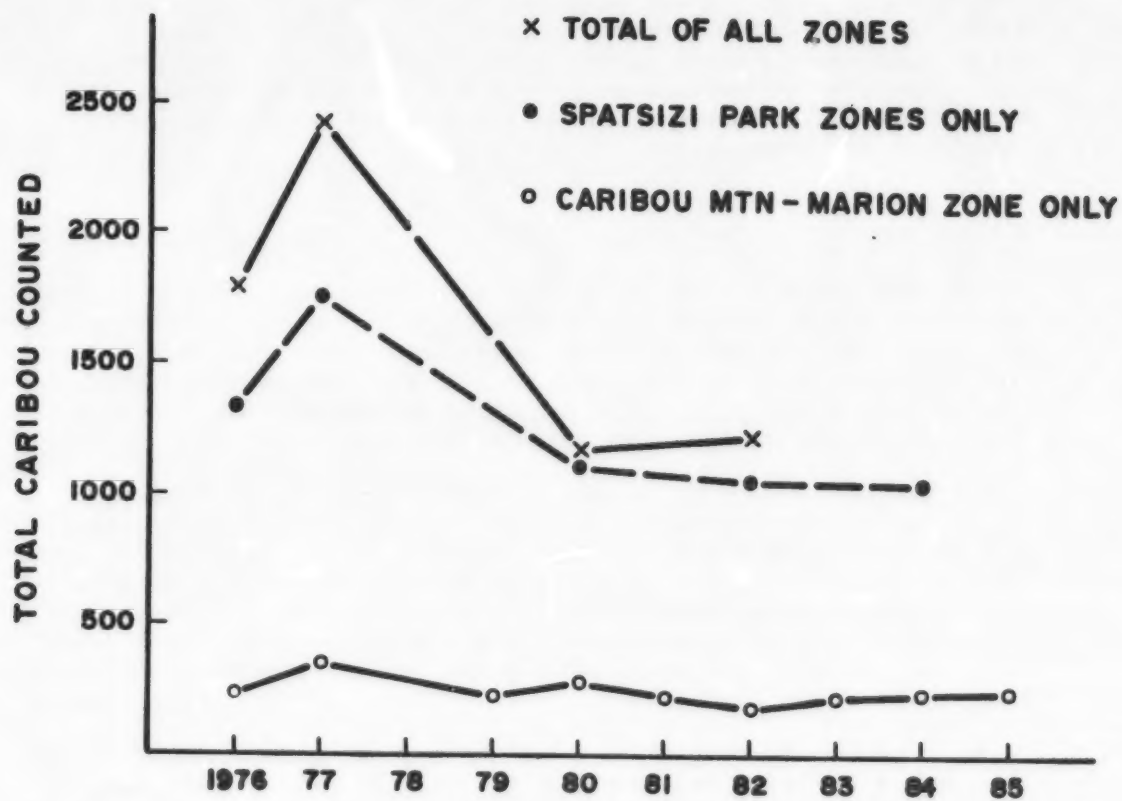


Figure 3. Trends in Total Caribou Counted from 1976 - 1985

The age data show that the proportion of harvested caribou in the 4-6 year age class increased between 1978 and 1984, and the proportion in the older age classes decreased. Considering the increases in recruitment and sex-ratio (Figure 4), the lowered age structure of the harvest probably resulted from increased numbers of young bulls in the population.

Taken together, the total counts, the observed caribou population demographics, the available information on predator abundance, and the age-distribution of the harvest, suggested the following working hypothesis concerning the caribou population:

1976 - 1978: recruitment, sex-ratio, and total numbers of caribou were reduced by predation;

1979 - 1985: recruitment and sex-ratio improved due to reduced rates of predation and the population stabilized, continued predation prevented a substantial population increase.

Considering the known variability of caribou surveys, it is recognized that the preceding scenario is not immune to debate. However, the hypothesis is consistent with the available information, and with the studies of Bergerud and Butler (1978) and Page (1985) which concluded that predation by wolves and grizzly bears reduced recruitment, sex-ratio, and caribou populations in Spatsizi Park.

4. Caribou population estimate

Prior to 1980 there were no quantitative criteria which could be used to estimate caribou populations from the inventory data. However, for management purposes a conservative population estimate was calculated on the assumption that the aerial surveys found 90% of the caribou. Consequently the population was estimated at 1900 caribou in 1977 when 1753 were observed, and at 1400 caribou in 1980 when 1260 were observed. It was suspected that the surveys found most of the caribou within the alpine habitats searched, but that unknown numbers were in habitats and areas not surveyed.

In 1981 an intensive caribou radio-tracking project was initiated by the Spatsizi Association for Biological Research. Several subsequent inventory surveys used the tagged animals in a blind and independent manner to estimate caribou population size from the total counts. The surveys found 86% (26/30) of the tagged caribou in the survey area, 65% (13/20) of the tagged caribou in the park, and 54% (13/24) of the total tagged caribou (Hatler pers. comm.). For the purposes of park management, the current population estimate of 1600 caribou in the park assumes that the 1041 caribou counted in 1984 were 65% of the caribou within the park. However, the total population within and outside the park was obviously larger.

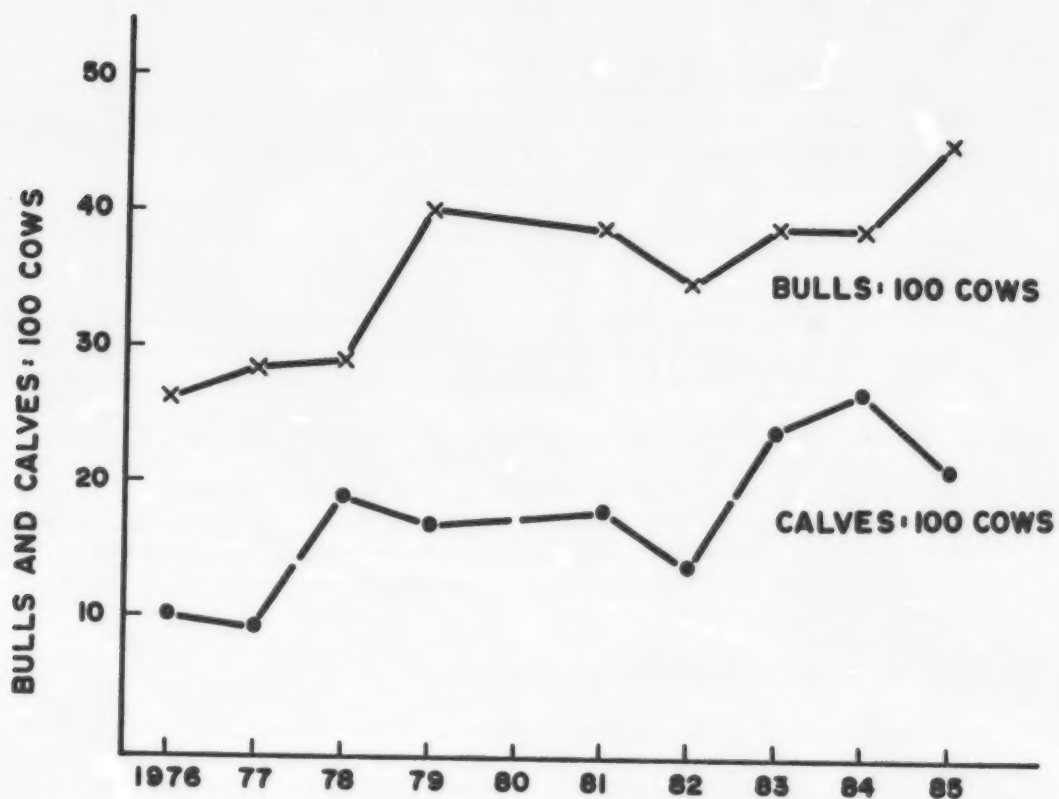


Figure 4. Trends in Demographics of Caribou Populations from 1976 - 1985

5. Caribou harvest objective and summary

Harvest data for 1978-1984 showed that 96% of the bull caribou harvested were 4 years and older. Since the management objective was to increase the proportion of males in the population, it was essential to estimate the net annual recruitment into the harvested age class. Using the observed proportions of calves and small bulls in the survey data, assuming 7.5% annual mortality to 4 years of age and 10% afterwards (Bergerud pers. comm.), the net recruitment into the 4 year old bull class was calculated at about 3% of the population. Since an increase in the sex-ratio was desired, only one-half of the net recruitment was allocated for harvest. Therefore the maximum desired harvest rate was set at 1.5% of the total population, or 15 4-year plus bulls per 1000 caribou in the fall. While this is a low harvest rate, an increase would only be possible if recruitment of calves and young bulls improved from the relatively low levels prevalent through 1985.

Given the estimated population of 1600 caribou in the park, and the 1.5% harvest rate, the objective was to harvest an average of 24 bulls per year. The actual mean harvest from 1983 through 1985 was 21 caribou per year. Although the caribou harvest objective was relatively low, actual harvests were lower and therefore non-resident quotas and resident LEH were both increased. Non-resident quotas were increased from 17 to 21 caribou, and resident LEH from 20 to 52 licences, between 1980 and 1985. B.C. residents took 20% of the caribou harvested, and therefore resident LEH was increased more than the non-resident quotas to increase the resident share. However, resident success rates averaged about 17% because the park is large, remote, hard to hunt, and therefore it was difficult to increase the resident harvest within the restraints of the LEH system.

DISCUSSION

1. Inventory

The results of the intensive inventory showed considerable inconsistency of total counts over a time period of two weeks or less, and showed that trends in total counts from one zone failed to match trends suggested by counts over the whole area. These results indicated that single counts taken annually from one part of a caribou population range during the rut would probably not show accurate population trends over a multi-year period. Evaluation of the data showed that proportion of calves and bulls decreased with increasing group size, indicating that all groups observed must be completely classified to minimize bias in calculated population ratios.

Considering the characteristics of caribou inventory data, interpretations of population status should not be based on single counts. Continued research is essential to improve inventory methods, but current knowledge suggests the following scheme for Spatsizi Park:

- a) attempted complete counts on all 3 rutting areas every 5 years, accompanied by a tag-resighting index, to estimate total numbers;
- b) sample population demographics over all 3 rutting areas annually, to estimate harvest rates and population changes.

The inventory scheme will be modified as necessary to incorporate improved information and management requirements.

2. Management

The management strategy of determining harvest objectives directly from inventory data greatly increased credibility with all concerned user groups. Initial harvest objectives were based on conservative population estimates which were adjusted as new information became available. While the 1.5% harvest rate seems low, this rate approximated 50% of the recruitment into the harvested sex-age class and therefore was biologically significant. An increased harvest rate would only be used when justified by new inventory data, research results, or analysis from techniques such as simulation modelling.

While the combination of difficult hunting conditions and LEH impaired resident success rates, LEH was retained in the park to prevent over-harvest and to demonstrate management control to the public. However, resident success rates may be increased in the future by improving the knowledge available to applicants and licence holders.

The basic conservative harvest strategy was useful, and may serve as a model for other areas. The inventory data for caribou in Spatsizi Park suggest that recruitment was below potential, and therefore tight management was considered necessary to protect the resource while maintaining the harvest.

The radio-telemetry study clearly showed that the natural range of the caribou population extends substantially beyond the park boundaries (Hatler 1985). Part of the provincial strategy for caribou management should be to determine population ranges, and then to manage on the basis of these populations. Present caribou management is based on administrative boundaries, while management based on populations would provide for better protection and use of the resource.

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CHAPTER 4 FUTURE DIRECTIONS IN CARIBOU RESEARCH AND MANAGEMENT

4.1 NEW DIRECTIONS IN CARIBOU MANAGEMENT AND RESEARCH

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Forest and wildlife managers in British Columbia are faced with the problem of managing forests to produce both timber and caribou. Managers have been frustrated by inadequate information on the general biology, habitat requirements, distribution, and population status of British Columbia caribou. It is clear that research in those areas is needed. As a starting point for a research program, a status report and problem analysis on caribou and caribou/forestry management has been prepared (Stevenson and Hatler 1985).

The objectives of the study were:

- i. To review and assess available information on the distribution, population status, and management (including harvest) of caribou in southern and central British Columbia
- ii. To review, by region, the existing information on seasonal habitat use, food habits, and other aspects of the animals' ecology
- iii. To review, by region, the patterns of forest harvesting, silvicultural treatment, fire history, insect attack, and other human activities and natural phenomena that affect caribou habitat
- iv. To describe the pattern and age of forest stands currently available to caribou
- v. To review the status of forest management planning and the pressure on the timber supply in the Timber Supply Areas (TSA's) that support caribou, in order to assess the potential impact of the timber supply on the animals
- vi. To review current policies for habitat protection in caribou areas, and the options that are available for integrating caribou management and timber harvesting
- vii. To review the current ideas about factors affecting numbers of large ungulates, especially caribou
- viii. To assess the extent and quality of currently available information
- ix. To make recommendations regarding research topics, hypotheses, priorities, and study areas
- x. To make recommendations regarding needs for management analysis.

The geographic area of the study was the southern half of British Columbia, that is, that portion of the province lying south of Highway 16 between Prince Rupert and Prince George, and south of Highway 97 between Prince George and Dawson Creek (Fig. 1). Those boundaries were chosen because the potential problems arising from timber harvesting in caribou habitat are more severe and immediate in that part of the province than in the north.

We refer to caribou occupying ranges in the western portion of the study area and east of the Rocky Mountains as "northern caribou". Northern caribou inhabit a geographic area in which winter snow conditions commonly permit the use of terrestrial vegetation as forage. We refer to caribou in the remainder of the study area as "mountain caribou". In the range of mountain caribou snowfall is heavier, and arboreal lichens are commonly used as winter forage. We believe that that distinction, originally made by Bergerud (1978), is a useful one for managers to recognize.

Our study lasted from 1982 to 1985. Most interviewing and data collection took place in 1982. Major points, but not details, were updated in 1984.

To meet our objectives, we undertook five major activities:

1. Reviewing the status of populations and habitat by regions (Objectives i-v and first half of vi)
2. Reviewing options for integrating forest harvesting and caribou management (second half of Objective vi)
3. Evaluating existing information on populations and habitat (Objective viii)
4. Preparing management recommendations (Objective x)
5. Preparing research recommendations (Objective ix).

In this paper, we discuss only Activities 4 and 5. We summarize the frameworks we developed for identifying geographic management priorities and for determining research needs. Our emphasis is on the approach rather than on specific conclusions. The reader is referred to the complete report (Stevenson and Hatler 1985) for more detailed information.

MANAGEMENT ANALYSIS

Rationale

Caribou management in British Columbia is the responsibility of the Wildlife Branch of the Ministry of Environment. The objectives of that agency for caribou management are to increase the population to at least 20 000 animals distributed on traditional ranges, to provide an opportunity for people to view caribou in their natural habitat, and to provide 20 000 hunter days of recreation and an annual sustained hunter kill of about 1000 animals (B.C. Ministry of Environment 1979).

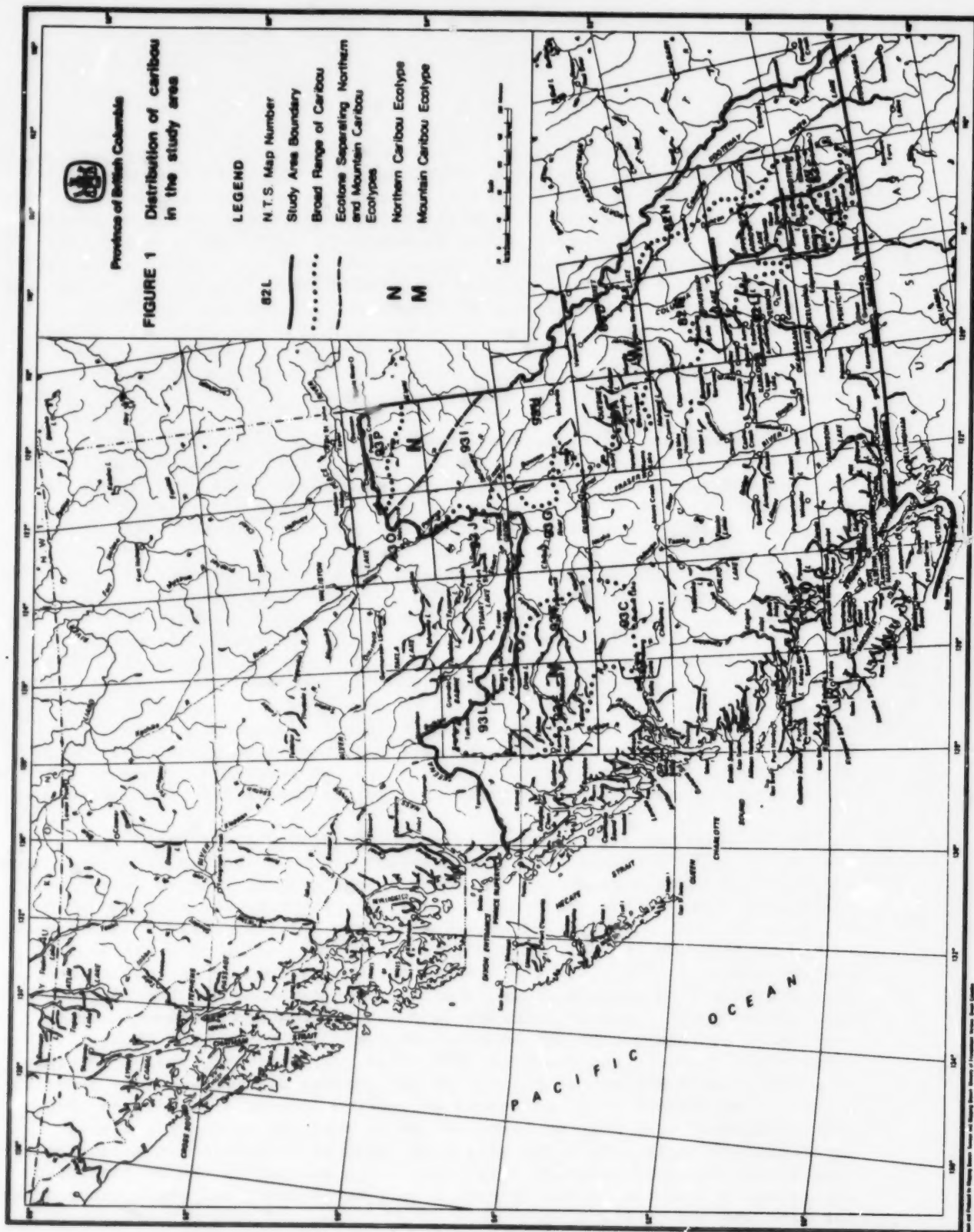


Figure 1. For greater detail see Stevenson and Hatler (1985), Figure 1, p. 3.

Although the Wildlife Branch has management responsibility for caribou, it does not have direct control over the land base on which caribou depend. Administrative control over Crown land occupied by caribou is primarily the responsibility of the Ministry of Forests, although the Ministry of Lands, Parks and Housing and other agencies have some jurisdiction as well. The Ministry of Forests is responsible for planning "the use of the forest and range resources of the Crown so that the production of timber and forage; the harvesting of timber; the grazing of livestock; and the realization of fisheries, wildlife, water, outdoor recreation and other natural resource values are coordinated and integrated, in consultation and cooperation with other ministries and agencies of the Crown and with the private sector" [Ministry of Forests Act 1980, Section 4c].

In this section, we offer some thoughts on what could be done at a provincial level to help meet management objectives for caribou. In much of the study area, caribou populations have declined, especially in parts of southeastern British Columbia where human activity has been most extensive. Our present level of knowledge does not allow us to eliminate either human activity or man-caused habitat alteration as causes of declines of caribou populations in the study area. We believe that the probability of sustaining caribou in southern British Columbia will be greatly increased if some areas are designated in which caribou management is a high priority. Because the costs of conservative management are high, it is important to concentrate efforts in those areas where they are most likely to be successful. If some areas are to be managed with stringent constraints, then other areas must be managed with few or no constraints. At present, wildlife managers lack guidelines to assist them in placing priorities on geographic areas to be managed for caribou production. The development of such guidelines would require planning at a provincial level. Here, we propose a framework which we think can help managers select areas for various levels of caribou management.

We reviewed the literature on island biogeography and related ecological theory for principles that might be relevant to the selection of special areas for single-species management. Although a single large reserve is commonly considered to be better than multiple smaller reserves, the biogeographic evidence for that principle is equivocal (Higgs 1981; Simberloff 1983), and it is not necessarily the best strategy for the preservation of a particular species (Bunnell 1978). In the case of caribou, a single continuous management area would have to be very large -- much larger in area than the largest disturbance patch (such as wildfire) and large enough to include internal recolonization sources in case a population is eliminated by a local catastrophe (Pickett and Thompson 1978) (Fig. 2A). Alternatively, multiple management areas may be manipulated as "artificial archipelagos" in order to minimize the chances of simultaneous extinction in each area (Wilcox 1980). Each management area must be large enough to meet the needs of a viable population of caribou, and the assemblage must be located in an arrangement that allows intercolonization (Fig. 2B). Both strategies can be justified biologically, but the latter is more likely to be practical where other demands for land use are conflicting.

BIOGEOGRAPHIC OPTIONS FOR SPECIAL MANAGEMENT AREAS

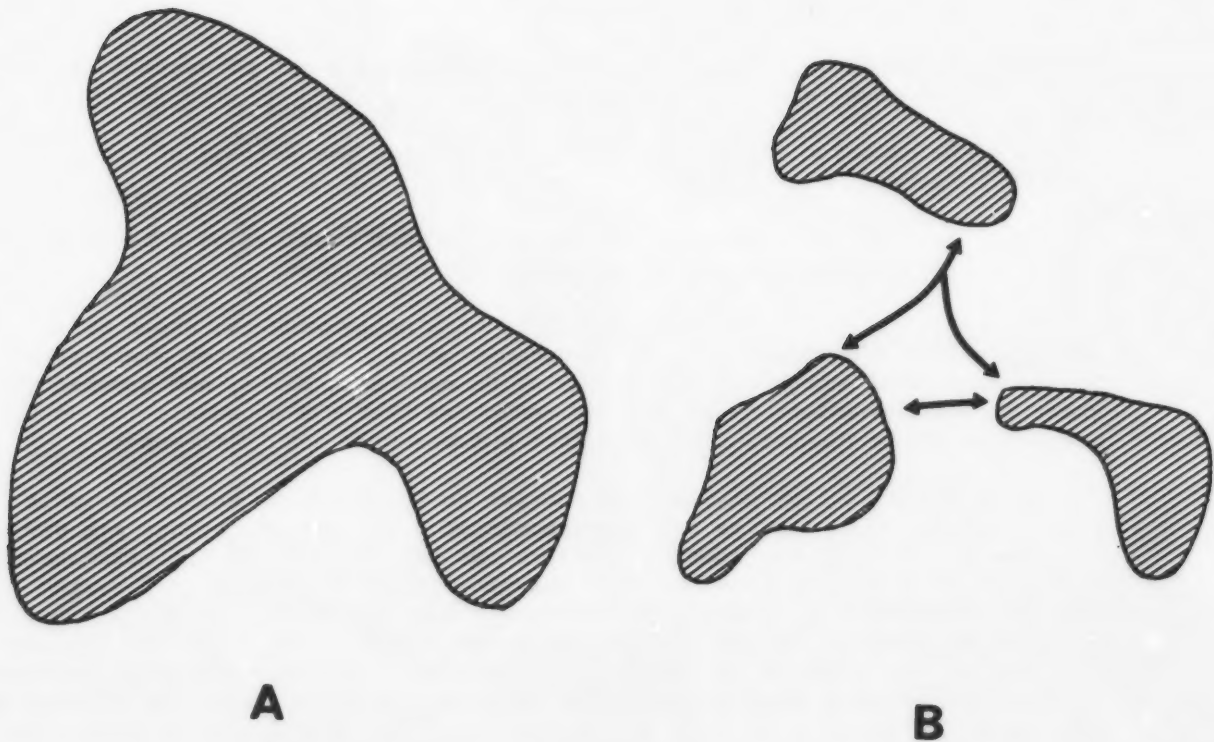


Figure 2. Spatial arrangement of caribou management areas.
a. one large self-sustaining reserve
b. smaller inter-dependent reserves.

Methods

We used a 5-step approach to the selection of areas for various levels of caribou management:

1. We divided the study area into geographic units.
2. We rated each geographic unit according to a set of specific factors that are relevant to management.
3. We rated each geographic unit according to a set of overall factors that are relevant to management.
4. We prepared a set of map overlays showing the ratings of the overall factors.
5. We used the resulting combinations of map overlays as a basis for recommendations regarding management priorities.

For consistency, and for compatibility with management, we chose to use administrative boundaries for our geographic units. We selected Ministry of Environment Game Management Units (GMU's) as our basic units, and grouped them where it was convenient to do so. We recognize that the boundaries of actual management areas identified through this process will need refinement.

We developed a list of specific factors to be rated for each geographic unit. The specific factors and the associated criteria for ratings are given in Table 1. Some of the specific factors can affect research and management decisions in a variety of ways. For example, a well-developed road system affects management by limiting the manager's ability to control disturbance, and affects research by reducing travel costs. Most of the specific factors are used in the criteria for the overall ratings. A few -- Mobility, Ecotype, Biogeoclimatic Zone, Physiographic Region -- are descriptive of the habitat or the manner in which it is used by the animals, and are included to help managers ensure that a variety of types are included in their considerations. We are not sure of the significance of differences in mobility among (and perhaps within) populations, but we feel that managers should be aware of them. They may affect the responses of caribou to habitat changes, such as linear developments, or to management techniques, such as relocation of animals.

We used the specific factors to develop a set of criteria for five overall ratings: biological viability, degree of habitat disturbance, conflicting land use pressures, level of knowledge, and public use and interest (Table 2). Our ratings of biological viability are based on caribou numbers and on degree of isolation, because we have some information about those specific factors for the entire study area. Recruitment and population trend are also relevant to the assessment of biological viability, but our information was too scattered in time and space to be used consistently in determining overall ratings.

TABLE 1. Management analysis: criteria for specific ratings

Reliability

- A - Judgment based on substantial evidence
- B - Judgment partially supported by evidence
- C - Guess

Numbers

- 1 - < 35
- 2 - 36-99
- 3 - 100-299
- 4 - >300

Recruitment

- 0 - No information
- 1 - < 10%
- 2 - 10 - 15 %
- 3 - > 15%

Population trend

- 0 - No information
- 1 - Declining
- 2 - Stable
- 3 - Increasing

Degree of isolation

- 1 - No contact likely
- 2 - Intermittent contact likely
- 3 - Regular contact likely

Mobility

- 0 - No information
- 1 - Summer and winter ranges geographically separate
- 2 - Summer and winter ranges in the same area

Ecotype

- M - Mountain
- N - Northern

Biogeoclimatic Zones

- AT - Alpine Tundra
- BWBS - Boreal White and Black Spruce
- ESSF - Engelmann Spruce - Subalpine Fir
- ICH - Interior Cedar - Hemlock
- IDF - Interior Douglas-fir
- MS - Montane Spruce
- SBS - Sub-Boreal Spruce

TABLE 1. Continued

Physiographic regions

- IP - Interior Plateau
- SRM - Southern Rocky Mountains
- CM - Columbia Mountains
- NRM - Northern Rocky Mountains
- CPM - Central Plateau and Mountain Area
- AP - Alberta Plateau

Impact of logging (excluding access)

- 0 - No impact
- 1 - Logging peripheral to caribou ranges, or only a small proportion of the area has been affected
- 2 - Logging has affected at least one important habitat type or geographic area used by caribou
- 3 - Logging widespread within caribou ranges

Impact of insect attack

- 0 - No epidemic insect attack
- 1 - Insect attack is minor or is not affecting forest harvesting in areas used by caribou
- 2 - Moderate or sporadic insect attack affecting forest harvesting in areas used by caribou
- 3 - Severe and widespread insect attack affecting forest harvesting in areas used by caribou

Impact of fire (since 1940, except where earlier fires are discussed in text)

- 0 - No known fires
- 1 - Fires peripheral to caribou ranges, or only a small proportion of the area used by caribou is in early seral stages (up to pole-sapling) because of fire
- 2 - Fires have affected at least one important habitat type or geographic area used by caribou
- 3 - Widespread fires have resulted in large areas within caribou ranges in an early seral stage (up to pole-sapling)

Access development

- 1 - Access only by trails, lakes, rivers, or air
- 2 - Portions of caribou ranges accessible by road
- 3 - Well-developed road systems, or roads into the alpine, provide access to large areas of caribou range

Other developments

- R - Reservoir
- HS - Permanent human settlement
- P - Oil and gas exploration and/or extraction
- M - Mineral extraction
- RR - Railroad
- HW - Highway
- REC - Recreation (e.g. snowmobiling, skiing)

TABLE 1. Continued

- 0 - No development
- 1 - Development peripheral to known caribou ranges
- 2 - Development affecting at least some of population
- 3 - Development affecting large proportion of population

Public interest in caribou

- 1 - Average level of public interest
- 2 - Special interest at local or regional level (because of visibility, media coverage, interpretive programs)
- 3 - Special interest at provincial or higher level

Consumptive use

- 0 - No legal hunting
- 1 - Legal kill 0-2 caribou/year
- 2 - Legal kill 2-10 caribou/year
- 3 - Legal kill > 11 caribou/year

Pressure on timber supply

- 0 - Local circumstances allow considerable flexibility
- 1 - No special long-term or short-term supply problems
- 2 - Long-term supply problems: Long Run Sustained Yield 80% or less of current AAC
- 3 - Short-term supply problems: 20-year supply inadequate, and no local mitigating factors

Resource developments planned

- R - Reservoir
- HS - Permanent human settlement
- P - Oil and gas exploration and/or extraction
- M - Mineral extraction
- RR - Railroad
- HW - Highway or major new access
- REC - Recreation

- 0 - No development
- 1 - Development peripheral to known caribou ranges
- 2 - Development potentially affecting at least some of population
- 3 - Development potentially affecting most of population

- X - Development underway
- Y - Development planned
- Z - Development under consideration

TABLE 1. Concluded

Research

- 0 - No studies
- 1 - Short-term or single-faceted studies, or studies that are primarily compilations of existing information
- 2 - Radiotelemetry studies of one year or more, or other field studies adequate to provide information on several aspects of caribou biology

Inventory

- 1 - Incidental observation only
 - 2 - Sporadic and/or few inventory flights
 - 3 - Regular and/or frequent inventory flights
-

TABLE 2. Management analysis: criteria for overall ratings

Biological viability

- A - Centre of large population (500+) with opportunities for regular contact with neighbouring groups
- B - Centre of moderately large population (250-500) with opportunities for regular contact with neighbouring groups
- C - Centre of moderately small population (50-250) with opportunities for regular contact with neighbouring groups
- D - Peripheral or poorly known
- E - Centre of small population (or 0-50) with little opportunity for contact with neighbouring groups

Degree of habitat disturbance

- H - Impact of logging, fire, access, or other developments high (generally, one or more ratings of 3A or 3B)
- M - Impact of logging, fire, access, or other developments moderate (generally, more than one rating of 2A or 2B)
- L - Impact of logging, fire, access, or other developments low or unknown (most ratings 1, or reliability C)

Conflicting land use pressures

- V - Very high; pressure on timber supply rated 3 or planned resource developments expected to have a high impact (usually rate 3X or 3Y)
- H - High; pressure on timber supply rated 2 or insect attack rated 3 or planned resource developments expected to have a moderate impact (usually rate 2X or 2Y)
- M - Moderate; pressure on timber supply rated 0 to 1 and planned resource developments expected to have a low impact (usually 1X or 1Y or Z)
- P - Provincial park

Level of knowledge

- M - Moderate; research rated 2 or inventory rated 3
- L - Low; research rated 1 or inventory rated 2
- N - Nil; research rated 0 and inventory rated 1

Public use and interest

- H - High; public interest or consumptive use rated 3
- M - Moderate; public interest rated 2 or consumptive use rated 1 or 2
- L - Low; public interest rated 1 and consumptive use rated 0

We then rated the specific factors and the overall factors in each geographic unit. Table 3 shows the results of that procedure for three of the 38 geographic units we used. The ratings represent our assessment of the situation in each unit, as of 1984. Although we have tried to tie the ratings to specific criteria, we recognize that they are partially subjective. Where relevant, we have rated the reliability of our assessments. Reliability ratings of habitat factors take into account both our knowledge of the factor and our knowledge of caribou habitat; a development may be rated "C" because we are unsure of its geographic extent, unsure of its impact on caribou, or unsure of the geographic range of caribou in that unit. We consider the framework itself to be more important than the ratings, which must be reassessed whenever the framework is applied.

In Table 3, all specific ratings and all overall ratings except biological viability are organized by GMU's or groups of GMU's. The ratings apply only to those portions of the GMU's lying within the broad range of caribou (Fig.1). In the case of our ratings of biological viability, we found it necessary to identify geographic areas that did not correspond to administrative boundaries. We mapped those centres of caribou populations that we were able to identify with the information we had; the boundaries are based on the apparent distribution of the animals. As better information on numbers and distribution becomes available, it is likely that other population centres within the broad range of caribou will be identified. Because the geographic units for the biological viability ratings do not correspond to GMU's the ratings are not given in Table 3. The population centres, classified by their biological viability rating, are shown in Figure 3.

We produced map overlays showing all five overall ratings, and the following combinations of map overlays:

- biological viability/public use and interest
- biological viability/level of knowledge
- biological viability/degree of habitat disturbance
- biological viability/conflicting land use pressures
- biological viability/degree of habitat disturbance conflicting land use pressures (Fig. 4).

Results

The results of the management analysis procedures are presented in detail elsewhere (Stevenson and Hatler 1985). Here, as examples of the kinds of recommendations that can be produced by our procedures, we wish to highlight the three population centres which we consider the best candidates for high-priority management areas. We recognize that these recommendations may be altered if ratings are revised, or if public use and interest are given a more prominent role in decision making.

TABLE 3. Management analysis framework

Management considerations	Game Management Units		
	3-35, 36	3-37, 41, 42	3-40
<u>Specific ratings</u>			
<u>Biological considerations</u>			
Numbers	2B	1B	1B
Recruitment	0	0	0
Population trend	0	0	0
Degree of isolation	3B	3B	3A
Mobility	0	1B	1B
<u>Habitat considerations</u>			
Ecotype	M	M	M
Biogeoclimatic zones	ICH, ESSF, AT	ICH, ESSF, AT	ICH, ESSF, AT
Physiographic region	CM	1P, CM	1P
Impact of logging	3B	3A	3A
Impact of insect attack	1B	2B	1B
Impact of fire	2B	3B	3A
Access development	3B	3A	3A
Other developments	0	HS-1B, RR-2C, HW-2C	HS-1B, RR-2C, REC-
<u>Social and economic conditions</u>			
Public interest in caribou	1	1	2
Consumptive use	0	0	0
Pressure on timber supply-TSA	1	1	1
	Okanagan	Kamloops	Kamloops
Resource developments planned	0	0	0
<u>Level of knowledge</u>			
Research	0	2	2
Inventory	1	2	3
<u>Overall ratings</u>			
Degree of habitat disturbance	H	H	H
Public use and interest	L	L	M
Conflicting land use pressure	M	M	M
Level of knowledge	N	M	M

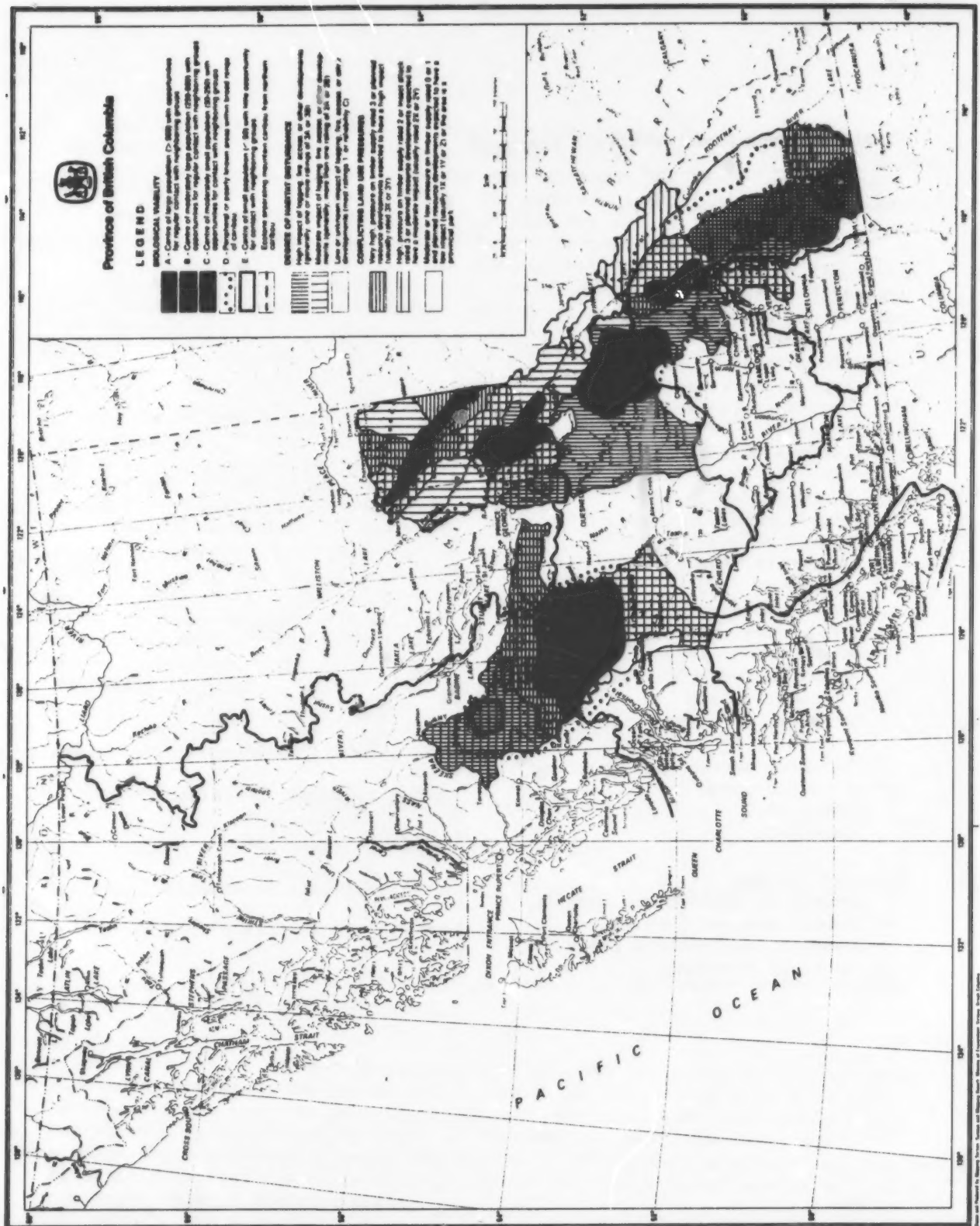


Figure 3. For greater detail see Stevenson and Hatler (1985), Figure 13, p. 277.

The Tweedsmuir Park population centre (Fig.4), which belongs to the northern ecotype, is characterized by high levels of both biological viability and public use and interest. Existing habitat disturbance is only moderate, but conflicting land use pressures are high in GMU 5-12 and very high in GMU 6-1. Resolution of those conflicts should be a high priority. Interchange between that population centre and the Telkwa population centre is likely; interchange with any other population centre is not likely. The Tweedsmuir Park population centre is significant as it is the southernmost extension of the northern ecotype. Because of the large size of the area and the fact that it apparently includes several of each type of seasonal habitats, it is probably adequate to maintain internal recolonization sources, and is a viable unit for the perpetuation of caribou.

The Wells Gray Park population centre and the population centre east of Prince George (Fig. 4) have the highest ratings for biological viability in the range of mountain caribou. A continuous distribution of animals, and therefore the possibility of genetic interchange and recolonization, exists among these two centres and populations in adjacent Alberta. Both centres are rated moderate in public use and interest. Both centres have moderate or high levels of existing habitat disturbance. Wood supply problems in the two areas, analyzed at the TSA level, are no greater than average, although accelerated harvesting is taking place in parts of GMU's 7-5, 7-6 and 7-18 because of spruce beetle attacks. Because of the moderate size of the two areas and the degree of habitat disturbance already sustained, we feel that it is necessary to designate both areas for high priority management in order to maximize the chances of perpetuating the mountain caribou ecotype.

Because of the uncertainty surrounding the effects of human activities on caribou, management constraints must be restrictive in key caribou ranges within high-priority management areas. Key caribou ranges must be identified. We recommend the following constraints on key caribou ranges in high-priority management areas for mountain caribou: 1) no industrial development; or 2) access control, partial cutting, and extended rotation. For northern caribou, we recommend 1) no industrial development; or 2) access control and restriction of logging to areas peripheral to key ranges. Because of the lack of information on the basic ecology of northern caribou, we are unable to make more specific recommendations regarding logging. Predator control may be considered for some high-priority management areas. An ongoing inventory program for high-priority management areas should be instituted. Designations of key caribou ranges and management constraints may be modified as more information becomes available.

We have not recommended specific areas for management on a medium priority basis, and we suggest that they be selected at a regional level. Provincial context should be one factor considered by regional managers in selecting medium-priority management areas. Potentially, medium-priority management areas can both enhance the viability of nearby high-priority management areas, and be enhanced by them.

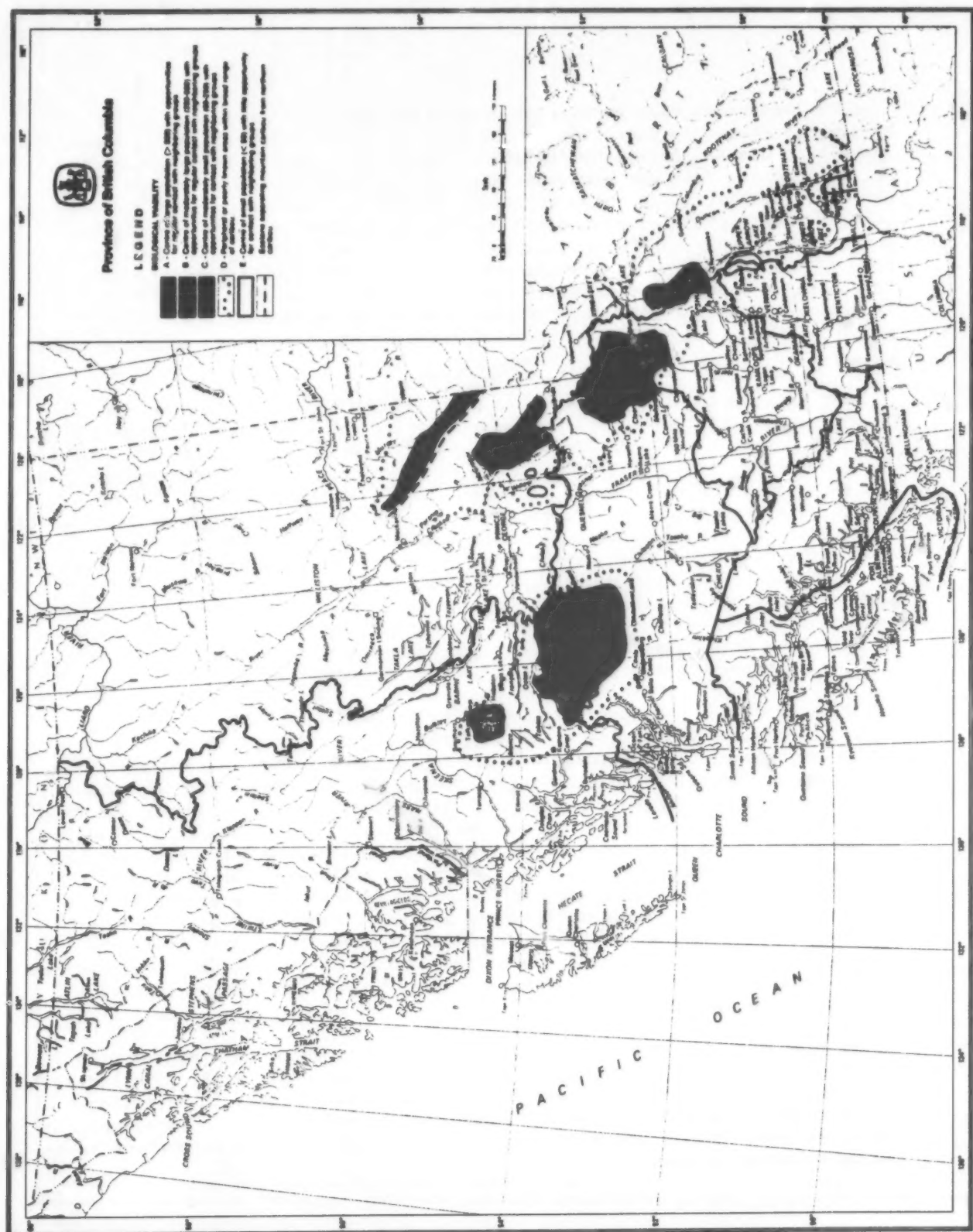


Figure 4. For greater detail see Stevenson and Hatler (1985), Figure 18, p. 287.

We are also unable to recommend specific management prescriptions for medium-priority management areas, because of the uncertainty surrounding the impact of various management techniques. Our recommendation is that managers select a strategy, such as minimizing the impact of access or attempting to maintain arboreal lichen production, apply it consistently in a given area, and monitor the results. Caribou populations in medium-priority management areas should be inventoried regularly.

To concentrate management effort and co-operation into those areas designated high and medium in priority, wildlife managers must be prepared to manage other areas with few or no constraints due to caribou.

Management Recommendations

To ensure that efforts to meet management objectives for caribou are concentrated in the geographic areas where they are most likely to succeed, we make the following recommendations:

Managers should consider the implications of biogeographic principles when placing priorities on geographic areas to be managed for caribou production.

Some areas should be designated in which caribou management is a high priority.

Designation of high-priority management areas should be done at a provincial level.

Key caribou ranges in high-priority management areas should be identified.

Management constraints in key caribou ranges in high-priority management areas should be restrictive.

Some areas should be designated in which caribou management is of medium priority. Medium-priority management areas should be selected, and management strategies determined, at a regional level.

Areas not designated as high or medium in priority for caribou management should be managed without costly constraints because of caribou.

RESEARCH NEEDS

Introduction and Rationale

The ultimate purpose of our study was to identify information needs that are relevant to the design of research programs. In the various chapters of the report we identified information gaps in specific local areas, discussed the dilemma and information needs of those attempting to manage forests to produce both timber and caribou, and described inadequacies in the existing data base. The information needs we identified vary in their importance and in their logical priority. To design effective programs, research planners need a way of organizing information needs and determining the order in which they should be addressed.

In our chapter on research needs we approached information requirements from a broader perspective than was the case in previous chapters. Recognizing that our understanding of the factors affecting population levels determines the direction of management and research, we briefly considered aspects of population regulation in caribou. We then developed an a priori research framework to help us consider as many areas of investigation as possible, and to set priorities for research. As the framework was applied, information needs identified in earlier chapters fell into place. We identified a set of broad questions which involve interactions among topics. Finally, we presented our recommendations for research topics and some considerations for the selection of study areas.

Aspects of Population Regulation

The literature on population regulation is voluminous, if not conclusive, with individual points of view favouring competition, physical characteristics of the environment, interspecific phenomena such as predation, physiological failure, behavioural factors, and even genetic changes. A full review of the subject was clearly beyond the scope of our report, although a brief consideration of factors potentially affecting wild cervids seemed warranted in the context of our research framework. It is generally recognized that any or all of the factors listed or implied above may act, singly or in combination, to reduce or limit numbers in any given local population of animals. The central question is whether there are any generalities applicable to particular animals. The factors that most consistently and significantly affect a species are the ones that should receive priority in both research and management deliberations.

Considering regulation among four species of North American cervids, the emerging hypotheses for mule deer (Odocoileus hemionus) (Mackie 1983) and moose (Alces alces) (Peek and Eastman 1983) are similar in that both cast features of habitat as "ultimate" factors, and relegate factors such as predation, disease, and weather to secondary or proximate roles. The situation for elk (Cervus canadensis) (Cole 1983) is somewhat different in that regulation is seen to be

primarily a social phenomenon, manifested as intraspecific competition for various resources. As with the moose and deer, however, extrinsic factors other than weather (e.g. predation) are seen only as modifying influences.

For the fourth cervid, caribou, Bergerud (1983) attributes no particular significance to habitat features per se in the control of populations. He postulates that those animals that live year round north of the tree line are controlled essentially by weather (which makes food unavailable and results in starvation), those in the "Lake State - Acadian Forests" declined from meningeal worm infestations, and those in the boreal and subalpine forests between (i.e., most caribou in existence today) are controlled primarily by natural and human predation.

Considering caribou in our study area, in a previous review Bergerud (1978) noted that predator numbers in southern British Columbia have generally remained low and recruitment has therefore been high. Because the caribou have nevertheless apparently declined in much of that area, Bergerud invoked overharvest by humans. Existing harvest data is equivocal. We concluded that Bergerud's (1983) synthesis warrants use as a source of stimulation and ideas for research, but not yet as a guideline for management.

The Research Framework

Biologists sometimes find that a major factor has been overlooked in a research program. That occurs for various reasons, including simple failure to consider all factors which might be relevant. In addition, opportunities to provide data on minor and/or subsidiary factors are passed up for lack of awareness of the potential. Our objectives in developing a research framework were:

- to ensure that as many as possible of the potential research and management activities are considered;
- to provide a means for establishing a hierarchy of activities;
- to provide a means for rating the importance of carrying out those activities;
- to identify research needs that were related to management objectives.

The provincial management objective for caribou is to increase numbers to 20 000 (B.C. Ministry of Environment, Fish and Wildlife Branch 1979). The greatest potential for increasing numbers lies in the north, but the overall provincial goal of maintaining species diversity within biophysical zones requires that caribou populations be maintained throughout their range. The basic management objective for the study area, then, is to maintain or increase caribou numbers, depending upon the area.

Attainment of that objective implies the desire to monitor population levels accurately. As discussed at length in the early sections of our report, we do not presently have that ability. For example, the stated objective for provincial populations (20 000 animals) already lies within the range of population estimates (10 000 to 20 000 animals). We therefore identified inventory as one of the broad categories of potential activities requiring consideration.

Population size is a function of productivity, immigration, mortality, and emigration. Although immigration and emigration may be important locally, we felt that they could be ignored on the broad scale of our study area. Having identified the basic categories of productivity and mortality, we listed the major components of those processes. Our lists were hierarchical and could be elaborated indefinitely; however, we limited ourselves to consideration of high-level components.

Having produced the hierarchical framework of potential research topics, we needed a procedure for determining which ones most needed investigation. We developed a set of three point (low-medium-high) scales for use in rating each category under the following headings: level of knowledge, importance, risk, inventory need, and research need (Table 4). To assess level of knowledge, we took into consideration both work done in the study area and work done elsewhere that we believed to be relevant to the situation in British Columbia. Importance, we defined, as importance in achieving management objectives. The highest ratings were assigned to those factors which, within the range of values we expected to encounter in our study area, we judged most important in determining population size or our knowledge of population size. We defined risk as the risk of failure in meeting management objectives if we had underestimated the importance of a topic; topics that were rated high in importance were not rated for risk. We then rated our need for more information about each topic, distinguishing between those needs that can be met by additional inventory of animals, and those that require research. We tried to maintain a practical orientation by posing the question: if managers knew more about this topic, what would they be able to do more effectively?

Application of the Research Framework

In our original report, each potential research topic was reviewed and discussed thoroughly to explain and justify the low-medium-high ratings assigned in Table 4. Here we provide abbreviated summaries of a few selected topics:

Inventory

Whether directed to questions relating to management or research, those activities that gather data on animal distribution, numbers or group composition in the field are collectively referred to here as "inventory". Under that general heading, three specific items were listed. Identification of populations and determination of distribution relative to seasonal movements

TABLE 4. Application of the research framework

Topic	Level of knowledge	Importance	Risk	Inventory need	Research need
INVENTORY	L	H	-	H	M
Identification of populations	L	H	-	H	L
Population dynamics (including numbers and composition)	L	H	-	H	H
Distribution (seasonal ranges and movements)	M	H	-	H	L
PRODUCTIVITY	M	M	L	M	L-M
Age of first breeding	M	M	L	-	M
% of females ovulating	H	L	M	-	L
% of ovulating females fertilized	M	M	M	M	L
% of pregnant females giving birth to live young	M	L	M	M	L
Twinning rate	H	L	L	L	L
MORTALITY					
<u>Proximate Factors</u>	M	M	M	-	M-H
Poaching	L	M	M	-	M
Traffic fatalities	M	M	M	-	M
Starvation	L	L	H	-	M
Accidents	L	L	L	-	M
Harvest	H	M	M	-	M
Disease and parasites	L	M	H	-	M
Predation	L	H	-	-	H
<u>Ultimate Factors</u>					
Cover	L-M	M	M	L-M	L-M
Thermal cover	M	M	M	L-M	L-M
Hiding cover	L	M	M	L-M	L-M
Insect cover	M	M	M	L-M	L-M
Food				L-M	L-M
Nutrients	L	M	M	-	L-M
Energy	M	H	-	-	H
Climate	L	H	-	-	L

and ranges are both first order needs in terms of inventory, but there is little need for research relating to those topics. That is, the technology exists for obtaining the required information; it involves marking individuals. The need is simply for it to be employed. There is no certain technology, however, for obtaining reliable information on numbers and composition of populations in the study area. There is therefore a need for research to develop and evaluate techniques that will enable the inventory needs to be met.

Productivity

Characteristics of productivity in caribou are known largely from work conducted outside the study area, but the overall pattern seems consistent enough to allow extrapolation to British Columbia. Productivity, which we defined as the average number of live young born per female per year, depends on twinning rate, breeding interval, age at first breeding, and the number of females giving birth to live young. Moderate research needs for age at first breeding is suggested by some variation in that factor among barren ground caribou, as recorded in papers we reviewed, and relative lack of relevant published information for woodland caribou. All information available indicated that multiple births in caribou are rare, and on that basis we assigned a high level of knowledge and low research need for that factor.

Despite an overall pattern of favourable birth rates in North American caribou, we concluded that there are several reasons for conducting inventory to ascertain that natality is indeed adequate throughout the study area. The consequences of failing to identify a productivity problem could be at least moderately serious. We consider fertilization of ovulating females to be a possible problem area. In hunted herds, there is a possibility that the number of males could be reduced to the extent that some females are not fertilized. In parts of southeastern British Columbia, the combination of habitat fragmentation and low numbers may have led to the failure of some females to be contacted by males during the rut. If so, then managers need information about habitat characteristics of rutting areas, the role of tradition in the selection of rutting areas, and fall movement patterns. A finding that natality is consistently adequate would eliminate the need for intensive research on that or other aspects of productivity at this time. However, we believe that natality should be continually monitored in areas where harvest levels are high or where major habitat changes are occurring.

Mortality

Two broad categories of mortality factors are listed in Table 4. Those affecting individual animals directly are considered proximate factors; ultimate factors are more subtle, affecting survival mostly by setting the stage for the various proximate factors to act. Generally, opportunities to document specific causes of caribou deaths in the study area have been few and there may be important factors that have yet to be identified. For that reason, all factors we listed were assumed to have at least a moderate research

need at this time. Probably the only technique that can provide pertinent information is radiotelemetry applied to a sufficient sample of individuals, until death, so that the relative contributions of the various factors can be assessed. Inventory is not considered applicable in improving knowledge about the proximate factors, since at best it can only identify changes in the numbers but cannot distinguish between death and emigration.

We listed and discussed 7 proximate factors. Five of those -- legal harvest, poaching, natural accidents, traffic fatalities and disease/parasites -- ranged from low to high in our theoretical level of knowledge, but all were judged to have a moderate research need. From all accounts, starvation is not expected to be a serious consideration in the study area, but our knowledge is low and the risk, if we are wrong in the assessment of importance, is high. We therefore also assigned a moderate research need for starvation.

The other proximate factor in Table 4, predation, is one about which little is known in the study area, and is the only one to which we assigned a high research need. Because of the currently high profile of predation deliberations in British Columbia wildlife management generally, and in the acknowledgement of Bergerud's (1978, 1983) hypothesis that predation is the primary limiting factor for caribou over most of their range, we here provide a more complete representation of the discussion from our original report (Stevenson and Hatler 1985).

The subject is complex. Although the bulk of Bergerud's (1983) predation discussion refers to wolves, he has implicated other potential predators including bears (Ursus spp.), wolverines (Gulo gulo), and golden eagles (Aquila chrysaetos), and has documented heavy local predation on caribou calves by lynx (Lynx canadensis) in Newfoundland (Bergerud 1971). Two other large carnivores, the coyote (Canis latrans) and the cougar (Felis concolor), are also common in some parts of the present study area. The effects of predation may be additive or compensatory for several predator species and may be specific to particular sex and age classes.

It is also important to consider the potential interactions between predation and other factors such as weather (Elliott et al. 1986) and apropos the context of this report, features of habitat. Bergerud (1978) noted that successional changes in habitat may result in local increases of moose and their predators (mostly wolves), and may thereby increase predation pressure on other local species including caribou. Habitat changes may also alter cover characteristics, providing new advantages for predator or prey. Developments such as roads, trails, and reservoirs may increase predator mobility or provide unprecedented access to important ranges, or both. Habitat changes that result in concentrating caribou on particular ranges or reducing physical condition could also increase vulnerability to predation.

We listed three broad topics (cover, food and climate) under ultimate mortality factors. We distinguished three types of cover: thermal cover, hiding cover and insect cover, and assigned low to moderate research needs for

all. Published evidence indicated that thermal cover was unlikely to be important enough to adult caribou to have population consequences, but because of its possible importance to newborn animals we judged it to be moderate both in importance and risk. It is not clear whether thermal cover is a factor in the selection of calving or postcalving habitat and, if so, whether the thermal cover in question is likely to be affected by man's activities. The question of the importance of hiding cover to caribou is directly relevant to the management question of whether or not to provide continuous forest cover along movement routes. We judged hiding cover to be moderate in importance and risk, and identified a need to gather information on this topic through intensive inventory work, research, or both. Insect cover was considered to be moderately important in its effect on population levels, but we do not know whether the need for insect cover has any management implications.

As an ultimate factor, nutritional status affects mortality by affecting the animals' ability to withstand other threats, such as predation and disease. We distinguished between the two essential resources provided by food, nutrients and energy. Of the various nutrients, we identified minerals as potentially the most important, but assigned a low to moderate research need for the topic as a whole. Energy, on the other hand, was seen to have high potential importance in terms of population consequences, and it was the only other topic, besides predation, assigned a high research need. The subject of energetics is complex, potentially interacting with most of the mortality and productivity factors we identified. After a review and analysis of seasonal energy supply and demand, we identified a need for an overall investigation of energetic relationships of caribou on an annual basis which would include the following questions:

- What are the relationships between harassing stimuli (insects, predators, humans) and the energetic status of caribou?
- What are the relationships between weather and snow conditions and the energetic status of caribou?
- What role, if any, do forests have in mitigating the effects of harassment and adverse weather on caribou?
- What are the relationships between the energetic status of females and calf survival?
- Given the energetic status of caribou at the beginning of winter and the energy demands on the animals during winter, is energy availability on winter ranges adequate?

The effects of climate as a mortality factor, through the direct action of weather, were discussed. We acknowledge the potential of long-term climate changes to affect the survival of caribou in the study area. For example, changes in winter snowpack might have a significant impact on caribou. However, we do not consider the effects of long-term climate change to be a viable research topic.

Interactions

Our need to organize and assess the variety of potential research topics listed in the research framework resulted in essentially separate treatment of the factors that may affect population levels. However, as suggested in the discussion of energy, we recognize that those factors are actually interdependent, and that some of the most critical information needs concern relationships among factors. Accordingly, we formulated some broad research questions. They are elaborated in the original report, but space permits only a listing here as follows:

- What is the relative impact on caribou of access development vs. habitat alteration in their ranges?
- Why do caribou select the habitats they do?
- What are the relationships among the quality and quantity of caribou habitat, caribou numbers, and animal condition?
- What are the relationships between animal condition and the response of caribou to stresses, such as predation, human disturbance, and insect harassment?
- What is the optimum size, shape and arrangement of habitat reserves for caribou?
- What variations in habitat selection strategies exist within ecotypes, and what are the implications of those variations for managers and researchers?
- What are the optimum conditions and methods for relocating caribou?

Selection of Research Areas

Selection of suitable study areas is one of the most important aspects in the design of a research project. The following list identifies some factors that should be considered:

Logistics - The distance of a potential study population from various facilities and services (e.g. living quarters, working quarters, air charter opportunities, road access and source of supplies) is important as it relates to research costs and a human convenience factor.

Biological Appropriateness - Some biological questions are more relevant in some geographical areas than in others.

Population Size - Certain kinds of research may require populations sufficient either to ensure adequate sample sizes or to allow methods that might be destructive to individual animals.

Public Use and Interest - Funding may be more easily justified for a population with a high public profile.

Experimental Design - Considering the specific topic of research, the best study area is the one with the fewest confounding factors.

Protection from Interference - Contingencies such as harvest of collared animals or development of research control areas can result in premature termination of projects or serious alteration of results.

Existing Information Base - The relative appropriateness of a particular research topic in a particular area may be evident on the basis of what is already known in that area.

Ability to Contact Animals - If animals are typically difficult to locate in a particular area, they may not be suitable for some types of research, particularly if telemetry is not used.

Management Priority - The suitability of a particular population may be partially dependent upon the question of what we need to know in relation to local management needs.

Extrapolation Potential - Some areas may be particularly desirable for study since they may enable extrapolation of results to other areas in relation to particular ecotypes, biogeoclimatic zones or physiographic regions.

Potential for Incidental Information - Obvious opportunities to gather additional data simultaneously or incidentally may make one area more desirable than another.

In addition to the above general consideration, we suggest the following specific study area selection principles for caribou in southern and central British Columbia.

1. Research effort should be directed to both the mountain and northern ecotypes.
2. Research effort should be applied in both developed and pristine areas, preferably comparing the two.
3. Given the relatively low level of knowledge about caribou over the entire range in the present broad study area, the areas with highest management priorities may also have the greatest research needs.
4. Local information can only be obtained from local studies, but local studies can provide information of more widespread and general applicability if the data are collected and compiled in a consistent manner and made available for synthesis. Research and inventory must be coordinated throughout the range of caribou in the province.

Although it will ultimately be up to provincial managers and researchers to select specific study areas, we also suggest that the three high management priority areas identified in the Management Analysis section (Tweedsmuir, Wells Gray Park and Prince George East population centres) should be given serious consideration.

Summary

We based our recommendations for research on an analysis of information needs, in the context of management objectives and of current history. Our analysis of information needs was based on an a priori research framework. We identified inventory, productivity, and mortality as three broad categories of potential research activity requiring consideration, the latter two because they are the basic biological processes determining numbers, and the former because it is the way we assess numbers. Within those broad categories we made hierarchical lists of their major components. We then rated each component according to existing level of knowledge, importance in achieving management objectives, risk of failure to meet management objectives if a component was more important than we had thought, and need for obtaining additional information.

By applying the research framework, we identified topics that require investigation through inventory, research, or both. Those topics are listed in descending order of perceived priority below. Topics rated low to moderate in priority do not necessarily warrant investigation on their own, but researchers and managers should be aware of the need to gather relevant information when opportunities present themselves.

Inventory Topics

High Priority Needs: Identification of populations and better information on numbers, composition and distribution in the study area.

Moderate Priority Needs: Assessment of adequacy of natality in most areas.

Low to Moderate Priority Needs: Evaluation of use of thermal, hiding and insect cover.

Research Topics

High Priority Needs: Development of methods for obtaining reliable information on numbers and composition of populations; Investigation of energetic relationships on an annual basis; Research on extent and nature of predation.

Moderate Priority Needs: Determination of the magnitude of proximate mortality factors other than predation; Determination of age of first breeding on various ranges.

Low to Moderate Priority Needs: Evaluation of use of thermal, hiding and insect cover; Investigation of mineral nutrition on various ranges.

We again emphasize that these inventory and research topics are not independent of each other and we do not propose them as discrete research packages; we listed them as we did in order to facilitate the allocation of effort. Recognizing that the factors that determine population levels of caribou are actually interdependent, we identified a set of the kind of broad biological questions which we feel should guide inventory and research activities undertaken under the categories listed above. Our list, which will not be repeated here, is not exhaustive. Prospective researchers may have viable arguments in any local situation for shifting priorities of individual topics and/or posing questions involving different or additional interactions from those we named. Research proposals and plans should justify what researchers are and are not going to do, and our research framework is designed to assist at that level. We do, however, have two major recommendations which specify particular directions in caribou research planning and administration, as follows:

- 1) Potential research study areas must be screened for a variety of factors that affect their suitability, but we recommend that first consideration be given to the three population centres recommended for high-priority caribou management.
- 2) To ensure that information obtained in local studies is compatible and available for synthesis, we recommend that caribou inventory and research be coordinated at a provincial level.

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4.2 CARIBOU DECLINES IN CENTRAL AND SOUTHERN BRITISH COLUMBIA

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Introduction

In this paper I will review the major factors that have been postulated to cause caribou declines in British Columbia caribou with disturbances. To evaluate declines, we must ascertain how the proposed decline factors upset the balance in the recruitment = adult mortality equation. A population can only decline if mortality exceeds recruitment. Commonly, biologists get side-tracked and talk about changes in distribution following disturbance without identifying how the disturbance affected the $M = R$ equation.

I apologize for not breaking new ground in this paper, but I believe this review is necessary in the light of the Stevenson & Hatler (1985) report. Stevenson and Hatler are generalists. They believe in the "plurality-of-causes" approach to declines. They repeat statements of declines attributed to drowning, distorted sex ratios, predation, reproductive failures, windchill, overhunting, starvation, etc. I believe this plurality approach is a backward step -- to say all is to say nothing. A great deal of caribou research has been done and most of the above factors have been eliminated as factors in decline.

To state that populations decline with logging is to say little about demographic factors that upset the recruitment-mortality equation. Logging could have resulted in the shift of the range of species such as deer (Odocoileus hemionus) and moose (Alces alces) (Edwards 1954) and caribou could have contacted new diseases as happened in eastern North America. The new prey species could have increased predator numbers and predator switch over (Bergerud 1974, 1978). Logging could have reduced food supplies and animals starved or had reduced reproduction. Logging could remove cover, increasing windchill or increased insect harassment. Logging improves the hunting success of natural predator and hunters by improved access. Thus noting the correlation between disturbance and caribou declines does not take us far down the road of understanding.

Inadequate Nutrition

One possibility is that caribou populations could decline following logging because of a reduction in reproductive rates or calf survival resulting from inadequate maternal nutrition. Seip (this volume) reported all the females they tagged were pregnant in the Quesnel Highlands in both their disturbed and undisturbed areas. Fecal nitrogen values in winter were similar between logged and unlogged (Table 1). Calf survival has generally been higher in disturbed southern British Columbia than in undisturbed northern British Columbia (Bergerud et al. 1984).

Seip has also provided fecal nitrogen values for females in the Quesnel Highlands in June for both early and late phenology years. These values are higher than corresponding values for females in the Arctic that migrate north hundreds of kilometers to calve at bleak and inhospitable calving grounds. These latter females generally calve two weeks before "green-up". The three Arctic herds in Table 1 are presently increasing (Seward 1985) and pregnancy rates are high (pers.). We have no evidence at this stage that food quality in logged or unlogged areas materially affects reproduction or calf survival below norms expected for caribou.

Nor can the argument be supported that a shortage of lichen foods is the cause of caribou declines such as that which has occurred in Wells Gray Park since 1977 (cf. Stevenson & Hatler 1985; Table 13). The lichen biomass is extremely high in Wells Gray compared to that of caribou on the Slate Islands, Ontario (Fig. 1). Both populations rely on arboreal lichens, Wells Gray because of deep snows, the Slate Islands because all the forage within reach has been eaten. Animals on the Slate Islands must wait for the wind to blow down lichens; these animals frequently hang themselves in the forks of trees by reaching for meager lichen supplies in deciduous trees. Yet the density of animals on the Slate Islands in 1984 was 17 animals/km² (pers.). Imagine this density of animals in the Wells Gray-Quesnel block of habitat -- there would be 200,000 animals; now in such a case there really would be a food shortage, but with 500+ animals there can be no absolute food problem.

In general in North America, caribou have only starved from a relative shortage of food (food unavailable because of snow and/or ice), rather than an absolute shortage (Table 2). Furthermore this type of starvation is much more common on islands than in open populations (Table 2). Starvation is an unlikely explanation for declines in British Columbia.

Windchill Mortality and Thermal Cover

Stevenson & Hatler (1985) suggest that caribou calves may die from windchill and the need for thermal cover should be investigated. The only reference for hypothermia that they provide is Hart et al. (1961). However, Hart et al. (1961) did not find calves that died from hypothermia. They conducted tests with captive calves. These calves were not on cow's milk and most were tethered. Cattle (1959) showed that tethered calves died from windchill and untethered did not. I have raised up to 150 calves on evaporated milk and know how poorly they do. Captive animals without their dams have decreased mobility, less shelter, less stimulation from licking and are not valid examples of natural hypothermia.

Caribou neonates in British Columbia do not face severe enough weather to die from windchill (Bergerud et al. 1984, Page 1985). Further, Kelsall's (1968) reports of windchill death of calves even in the Arctic have now been questioned (Miller & Gunn 1986). The windchill hypothermia has also been rejected for caribou in Norway (Skogland 1985) and animals north of the Brooks Range in Alaska (Davis & Valkenburg 1985).

Table 1. Fecal nitrogen comparisons as an index to forage quality.

<u>Date and Area</u>	<u>Fecal N</u>	<u>Comments</u>
<u>March (low in cycle)</u>		
C. Victoria, Ontario, February 27	1.8 $\pm$ 0.02	virgin range
Michipicoten Is., Ontario, March 30	2.0 $\pm$ 0.04	lush range
Montreal Island, Ontario, February 22	1.8 $\pm$ 0.19	new range
Coldwell Peninsula, Ontario, March 15	1.8 $\pm$ 0.17	undergrazed
Pic Island, Ontario, April 1	1.8 $\pm$ 0.04	overgrazed
Slate Islands, Ontario, March 20	1.6 $\pm$ 0.02	starving
George River, Labrador, March	1.5+ (large n)	largest herd in world
Quesnel Highlands		
Logged, March	2.2	Seip
Not logged, April	2.1	
<u>June at calving</u>		
Delta Herd Ak.	1.8 (n = 21)	only females, males
Forty-mile Herd Ak.	2.0 (n = 20)	much
Western Arctic	2.0 (n = 19)	higher
Quesnel Highlands		
Late spring, 1984	2.2 (n = 7)	Seip
Early spring, 1984	2.7 (n = 9)	Seip

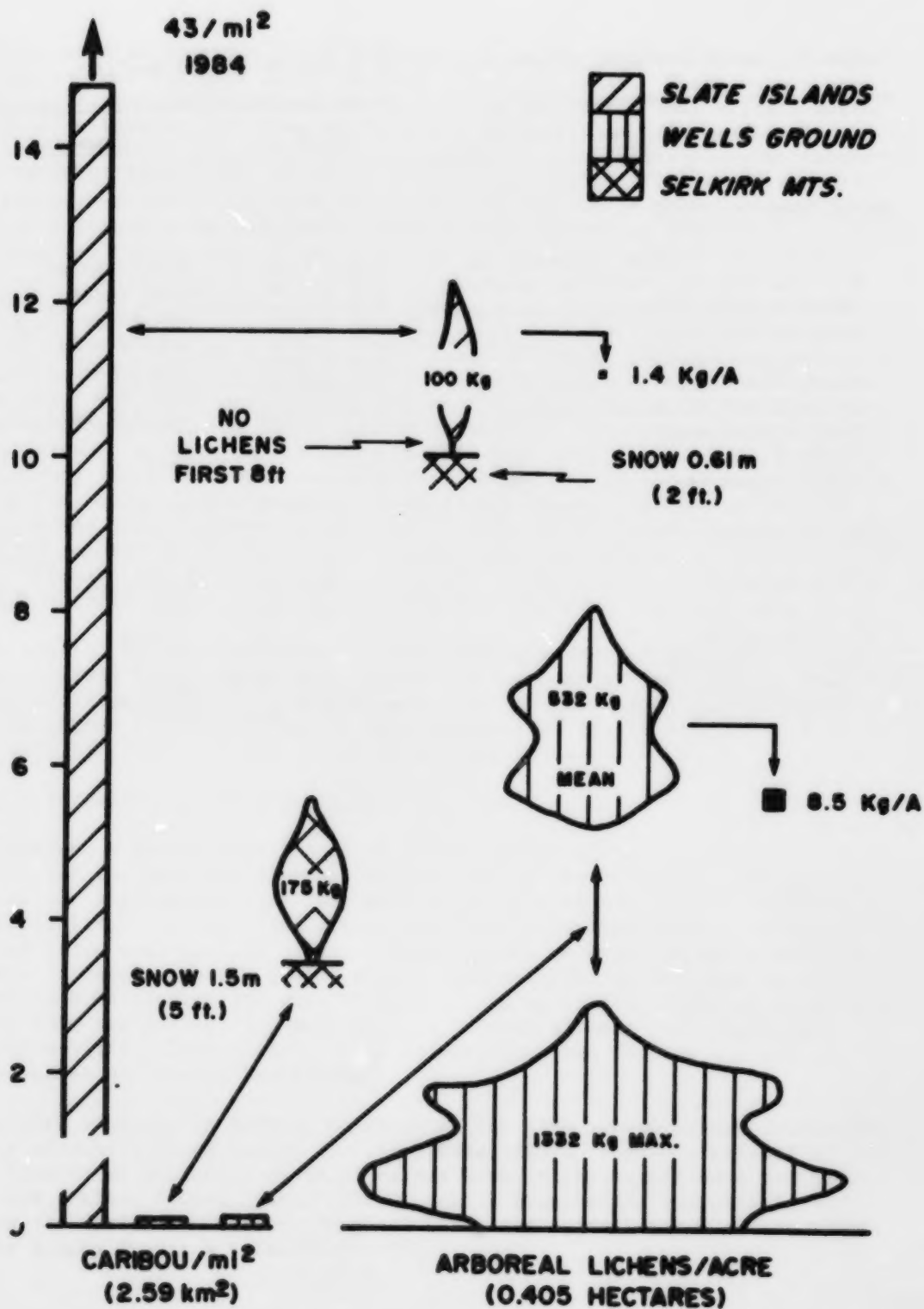


Fig. 1 Arboreal lichen supplies compared between the Wells Gray, Selkirk, B.C. and Slate Islands, Ont. and the density of caribou.

Again, caribou do not need thermal cover for either the very cold (Henshaw, 1964) nor the hot. Stevenson & Hatler provide no references for this speculation. Helle & Aspi (1984) show that caribou can even seek hot surfaces in summer where updrafts allow CO₂ to escape with warming air, which reduces the efficiency of insects in finding the animals.

Overhunting

In 1977, I found no biologists or outfitters who felt the herds were overhunted. I documented that new access was providing overharvest (Bergerud 1978), a point of view novel then, but now accepted. The harvest was reduced and the decline halted. The golden days of caribou hunting that had followed predator control in the late 1950's had passed; days that we will not see again.

Stevenson & Hatler (1985:295) state: "Because the caribou have nevertheless declined in much of the area (central and southern British Columbia), Bergerud invoked another form of predation, overhunting by humans, as an explanation but, as shown in Chapter 2, existing harvest data . . . generally do not support the case." The herds I listed in 1978 as declining from overhunting in central and southern British Columbia were the Telkwa, Tweedsmuir, and Yellowhead. For the Telkwa they state (p. 122): "It (overharvest) must have happened." For the Tweedsmuir they state (p. 137): "The fact of at least some degree of overkill seems well enough established." Lastly, for Yellowhead they state (p. 160): "The data listed in Table 9 are indeed suggestive (of overharvest) but are not conclusive." Clearly they cannot have it both ways, to be free to criticize my arguments for overharvest yet invoke the same explanation in their plurality approach.

They are especially critical in relation to my review of overhunting of the Telkwa herd. They list the herd as having opportunities to exchange animals with other herds (Fig. 13, p. 277) and sarcastically imply that I was "intent on preserving the view" that the herd was isolated. They provide no evidence that the herd exchanges animals with other herds and their data show no sighting of other caribou after 1968 within a 70 km. radius of the herd's range (Vol II, Mapsheet 17a). One animal was radio-tracked throughout the year and was found repeatedly with other animals on the same range. Radio tracking studies of other herds in the mountains have documented a fidelity over several years to calving ranges (Edmonds & Bloomfield 1984, Sopuck 1985). Further, the contours of deeper snow lie between the herd and the nearest adjacent herd (Tweedsmuir). The animals would have to move against the contours which they would not do. How is it that they feel this herd has opportunity for contacts with other herds, the nearest being 60 km. distant, yet they feel the herd west of Bowron River, only 15 km. from other herds, has little opportunity to contact other herds (Vol. I, Fig. 13, p. 277; Vol. II Mapsheet 8a).

The evidence supports my view that the Telkwa herd is isolated at low numbers and we are left with a known minimum population of 271 in 1965 and a minimum of 40 in 1968, and we have L. Cox's report of the heavy hunting that

occurred between 1965 and 1968. Cox states (in Bergerud, p. 138): "After one hunting season, 40 per cent of the caribou in the Telkwa Mountains could not be found."

Stevenson & Hatler have also used (p. 129) a sex ratio comparison in the winter of 1977 of 1 male:6.5 females ($n = 4$ males, 26 females, and 10 calves) vs. that in 1983 of 1 male:1.6 females ($n = 23$ males, 36 females, and 9 calves) as evidence that the Telkwa herd is not isolated and that past counts may have been inaccurate. They feel the sex ratio changed too quickly. Their argument is not valid. Males do have higher mortality rates than females especially when predation is high, but in 1977 calves represented 25% of the Telkwa population in the winter (24% in 1979) — predation would have been low. Further, they didn't appreciate the potential differential changes in the relative abundance of the two sexes when the proportions initially are extremely unbalanced. Assume a natural mortality of males and calves of 15% and 10% for females, winter to winter. Then in 1977-78 the loss of males is 0.6 (0.15×4) and for females 2.6 (0.10×26) and 1.6 calf. With male and female recruits divided 55% males and 45% females (Kelsall 1968, Skoog 1968) the sex ratio of the adults in 1977 will change quickly and would reach 1 male for each 1.6 females by 1983 (Table 3). Such changes have been documented in papers given at the conference for the Horseranch herd (J. Elliot) and for the Spatsizi population (G. Jones). In fact, this change in sex ratio means that the herd has indeed been isolated and better evidence than census data that the herd increased between 1977 and 1983. The increase in the proportion of males also support the view that counts have been reasonably precise.

To buttress their argument that I overemphasized the harvest of the Telkwa, they subtract the reported mean harvest of 26 animals, 1973-75, from MA 25 from a mean of 39 animals harvested 1967-73 to arrive at an annual harvest of 12 animals from the Telkwa. This comparison is not valid since the herd was still thought to be large 1965-66 (277 to 166 animals), but was only 40 animals by 1968. Few people will hunt for a population of 40, but many could have taken up the gun earlier with a reportedly large herd near town and cheap helicopter service available. Probably, as the census results suggest, the major harvests occurred in 1965 and 1966, and their comparison of harvests 1967-73 vs 1973-75 is meaningless. I have recorded the destruction of a caribou herd in Labrador by hunting in three seasons that was much larger than the Telkwa. The hunters were not natives and they came mostly from one community (Bergerud 1967). The only necessary ingredient for overharvest is that the animals be easy to reach and regulations liberal -- caribou are that easy to kill.

To support my hypothesis that the Tweedsmuir herd was overharvested, I provided hard data on the location of kills and a high harvest 1965 to 1973. Stevenson & Hatler (1985) provide no alternative hypothesis of decline supported by data. They speculate that animals could break through the ice or be caught in debris and drown, but provide no references. They quote a possible example of moose drowning elsewhere. Have they ever seen caribou break through the ice? Have they ever encountered animals swimming and noted

Table 2. Reported cases of caribou starving in North America^a.

<u>Type of Food Shortage</u>	<u>Years</u>	<u>References</u>
<u>Relative Shortage</u>		
Unimak Island, Alaska	1924-25	Skoog, 1968
Coats Island, N.W.T.	1974-75, 1979-80	C. Gates, pers. comm.
Alaska Peninsula, Alaska	1930-31, 1933-34, 1938-39	Skoog, 1968
Queen Elizabeth Island,	1973-74 and others	Parker et al., 1975
Beverly Herd, N.W.T.	Open population, 1961-62	Kelsall, 1968
Interior, Newfoundland	Open population, 1958-59	Bergerud, 1971
Banks Island	1977-78	Thomas, 1980
<u>Absolute & relative shortage</u>		
St. Matthew Island, Alaska	1963-64	Klein, 1968
St. Paul Island, Alaska	1939-40	Scheffer, 1951
Slate Island, Ontario	1973-74, 1976-77, 1984-1985	Personal file

^aOther examples outside North America where wolves are not present include Svalbard, Greenland, South Georgia, Norway, and U.S.S.R. Islands, Novaya Zemlya, Novosibirsk Islands & Wrangel

their swimming and floating abilities, compared to moose? I have handled several hundred swimming caribou. Oosta Lake is not Limestone Falls. It is by such unwarranted speculations that rumours get started that caribou can't cope with development, but who has supplied the hard data (Bergerud et al. 1984)? They correctly criticize Bloomfield (1979) for just such loose speculations.

Stevenson & Hatler (1985) attempted to discredit my scenario for the decline of the Yellowhead herds from hunting by calculating that my scenario would lead quickly to the extinction of all the males in the herd (their Table 10). However, in making their projections, they calculated recruitment incorrectly as well as the number of males and females dying from illegal hunting and natural mortality. My scenario was not based on an initial population of 625 and thus without benchmarks, as they claim. The scenario was based on K. Child's estimate of 200 animals in 1977 and was projected back in time. In writing their report they communicated with 98 people in the Province (p. 354), many of them without knowledge of caribou. Yet they discuss my data and/or ideas on 48 pages of their report but were not prepared to communicate with me on any aspects of these discussions, not even to clarify how my scenario (which they erroneously reconstructed) was calculated.

Stevenson & Hatler (1965:161) state: "The way Bergerud calculated the total population (Yellowhead) each year actually hastens the apparent decline. He subtracted all mortality from the previous year's population before calculating recruitment in each case." It is not clear how Stevenson & Hatler calculated recruitment in their Table 10, but my method was correct (Bergerud 1978, p. 61, footnote 3). For example, I listed the immediate preseason September 1 population in 1968 as 520, which included calves born in 1968 still alive in the fall. From this 520 total, we must first subtract the annual mortality, removing in sequence hunting, poaching, and lastly natural mortality; we can't have animals dying twice (123 animals) (Table 4). The remaining animals, 399 (520-123) will next September represent 83% of the population we classify, if recruitment of the 1969 cohort is 17%. Recruitment will equal $((397 \times 100)/83) - 397 = 81$ animals for the next year, not 68 animals as listed by Stevenson & Hatler. They also calculated to high a proportion of males dying from poaching and natural mortality (Table 4). With the proper calculations my scenario results in a sex-ratio low where there is a ratio of 1 male per 4 females, a common ratio in British Columbia (Bergerud, 1978:Table 31). Males can't go extinct from selective hunting, since hunters and most biologists can't distinguish 1- and 2-year-old males from females. These young males will still breed females. Again they criticize my use of a constant recruitment of 17% for the Yellowhead as "Maybe a serious oversimplification ... and is unlikely." They should have checked their own data for that Region and which for 8 years total gives a percentage of 16% (115/741). (Editor's note: Bergerud's scenario is correct.)

Throughout their paper, they harshly criticize my decline scenarios of overhunting, e.g., "Bergerud manipulated" or "wanting on accuracy", etc. Webster's defines a scenario "as a sequence of events especially when imagined "or again" a synopsis of projected causes of action". My scenarios were



theoretical exercises to decide if hunting could explain declines. The overhunting scenarios were convincing to other biologists. The seasons were drastically shortened or closed as a result of my report. Compulsory reporting of hunting results was adopted. Now the three caribou herds have all increased (Table 5). The Yellowhead herd has increased in the face of continued habitat degradation. These increases are clear evidence that the overhunting hypothesis was correct.

Predation

Stevenson & Hatler (1985:314) state: "Although Bergerud (1983) held that the major limiting factor for caribou over most of the species range is predation, we did not find that the relationship has been demonstrated for the present study area. Other factors affecting caribou numbers must also be considered." However, they do not provide one documentary example or reference of a British Columbia caribou herd being limited by "other factors."

Since I proposed that predation limited caribou within the centre of the species range in North America (Bergerud 1983) radios have been placed on 40 herds in North America. Eleven of the studies have reported the cause of adult mortalities; all list predation as the chief cause. Radios have been placed on newborn calves in three herds; again, the chief natural cause of death for all three herds was predation.

Let us look at the predation findings for mountain caribou (Fig. 2). Gauthier (1984) in his Ph.D. study of the Burwash Herd in the Yukon placed radios on both wolves and caribou. He concluded "predation, primarily by wolves, was the major limiting factor to herd growth."

R. Farnell placed radios on the Finlayson Herd in the Yukon. Five of 18 radio-collared (28%) caribou were killed by wolves in the first year. Calf survival was low. Wolves were reduced and calf and adult survival improved and the herd started to increase (Farnell, pers.).

J. Elliot monitored herd numbers and calf percentages for the Horseranch herd in British Columbia for seven years. Wolves were removed in three years and calf survival increased dramatically (Fig. 3) and the herd increased (Fig. 4). Although this research was criticized by C. Krebs of U.B.C., these findings have now received peer review and have been accepted as valid (Bergerud & Elliott in press; also see paper by Elliot presented at this conference).

R. Page radio-tracked young calves at Spatsizi Park. He documented (Page 1985, and this conference) that predation was the chief cause of death. Bergerud et al. (1984) also documented high mortality rates for calves. This herd declined between 1976-77 and 1980 because of low calf survival and, probably, high adult mortality (Fig. 4) (Bergerud & Elliot, 1986).

The one herd in British Columbia that has shown the most consistent population increase in the past ten years is the Ilgachuz-Itcha herd. I

Table 3. Increase of the Telkwa Herd from internal growth 1977 to 1983 based on annual mortality rates midwinter to midwinter of 15% for males and calves and 10% for females.

Winter Season	Total Adults		Total Calves		Total Herd	Percent Calves	Adult Females per Male
	Males	Females	Males	Females			
1977-78	4 ^a	26 ^a	5	5	40	25	6.5
losses	-0.6	-2.6	-0.8	-0.8			
gains	+4.2	+4.2					
1978-79	7.6	27.6	6.4	5.3 ^b	46.9	25	3.6
losses	-1.1	-2.8	-1.0	-0.8			
gains	+5.4	+4.5					
1979-80	11.9	29.3	7.5	6.2	54.9	25	2.5
losses	-1.8	-2.9	-1.1	-0.9			
gains	+6.4	5.3					
1980-81	16.5	31.7	6.6	5.4	60.2	20	1.9
losses	-2.5	3.2	-1.0	-0.8			
gains	+5.6	+4.6					
1981-82	19.6	33.1	7.2	6.0	65.9	20	1.7
losses	-2.9	-3.3	-1.1	-0.9			
gains	+6.1	+5.1					
1982-83	22.8	34.9	5.6	4.5	67.8	15	1.5
Observed March 23 1983	23	36		9	68	13	1.6.

^a observed December 1977: 4 males, 26 females and 10 calves

^b calculated: $[(35.2 \times 100) + 75\%] - 35.2 = 11.7$; assume 55% male calves and 45% female calves.

Table 4. Scenario of decline of Yellowhead herds from overhunting, modified from Bergerud 1978:Table 16 (calculated Sept. 1 to Sept. 1).

Sizes, losses and gains Y ₁ and Y ₂	Total Animals				Total	Mortality						Ratio Females/ Male	
	Adults		Calves ^a			Harvested		Poached		Natural			
	M	F	M	F		M	F	M	F	M	F		
1967	186	333	58	48	625	70	66	8	17	12	20	1.8	
losses	-86	-100	-4	-3									
gains	+54	+45											
1968	154	278	49	39	520	52	21	6	14	10	20	1.8	
losses	-65	-52	-3	-3									
gains	+46	+36											
1969	135	262	45	36	478	75	34	4	11	7	18	1.9	
losses	-83	-60	-3	-3									
gains	+42	+33											
1970	94	235	37	30	396	72	20	1	9	4	16	2.5	
losses	-74	-43	-3	-2									
gains	+34	+28											
1971	54	220	30	25	329	18	74 ^e	1	4	4	12	4.1	
losses	-21	-88	-2	-2									
gains	+29	+23											
1972	62	154	24	20	260	13	34	1	4	5	9	2.5	
losses	-19	-45	-2	-1									
gains	+23	+19	male only restrictions, 1.5 & 2.5-year-old										1.9
1973	67	127	males can't be told from females, hunters will report only males										

^a recruitment calculated after annual losses (fall to fall), example 1968 [(154 + 278)] x 100] ÷ 83X = 520, 520 - (154 + 278) = 88 calves, 88 x 0.55 = 49 male calves; 83 based on 17% population pre hunting comprised of calves.

^b assumes calves not harvested; resident & nonresidents combined

^c number of poached males & females based on proportions of males & females after hunting season

^d includes mortality of calves, natural mortality males, females, adults & calves all 0.07 (Bergerud 1978). Male mortality = female mortality, since males are mostly young, number calculated based on females & males remaining after hunting & poaching

- ^e Stevenson and Hatler (1985) assume residents shoot 38 males and 38 females. This is not possible, since >80% males are yearlings and 2-years-old and can't be told from females; sexes shot in proportion to their abundance.
- ^f based on a natural mortality of 0.07 (Bergerud 1978) recruitment of 0.16, and 225 animals left in 1977 Bergerud (1978). The population in 1985 should be 508 animals [$\lambda = (1-M)/(1-R) = 1.107 = (1 - 0.07)/(1-0.16)$] similar to the size of the herd estimated by D. King of 500 animals (pers. comm.)

Table 5 Growth of four caribou herds in Central British Columbia in recent years.

Herd Name	Previous Estimate ^a	Current Estimate ^a	Rate-of-increase
Telkwa	40 (1977)	71 (1982)	r = 0.11
Tweedsmuir	241 (1979)	500 (1985)	r = 0.12
Yellowhead	240 (1979)	500 (1985)	r = 0.13
Itchas	310 (1973)	1400 (1985)	r = 0.13

^a references Bergerud 1978, Hatter 1979, Marshall 1985, D. King pers. comm., Stevenson & Hatler 1985, T. Smith pers. comm..

^b Stevenson & Hatler (1985:198) state "numbers in three other areas (above excluding Yellowhead) have been demonstrated to be higher than previously thought by virtue of recent single counts which generally exceed Bergerud's population estimates". This statement can be questioned. Populations are generally changing size and the comparisons of counts several years apart is not evidence of inaccurate counts. We can judge whether populations are increasing by recruitment statistics, changes in sex ratios, and magnitude of projected rates-of-change. The above r values are all realistic. My estimate for N. Tweedsmuir in 1977 was 175 (75 + 50 + 50, Bergerud 1978:92) which gives a reasonable r of 0.13.

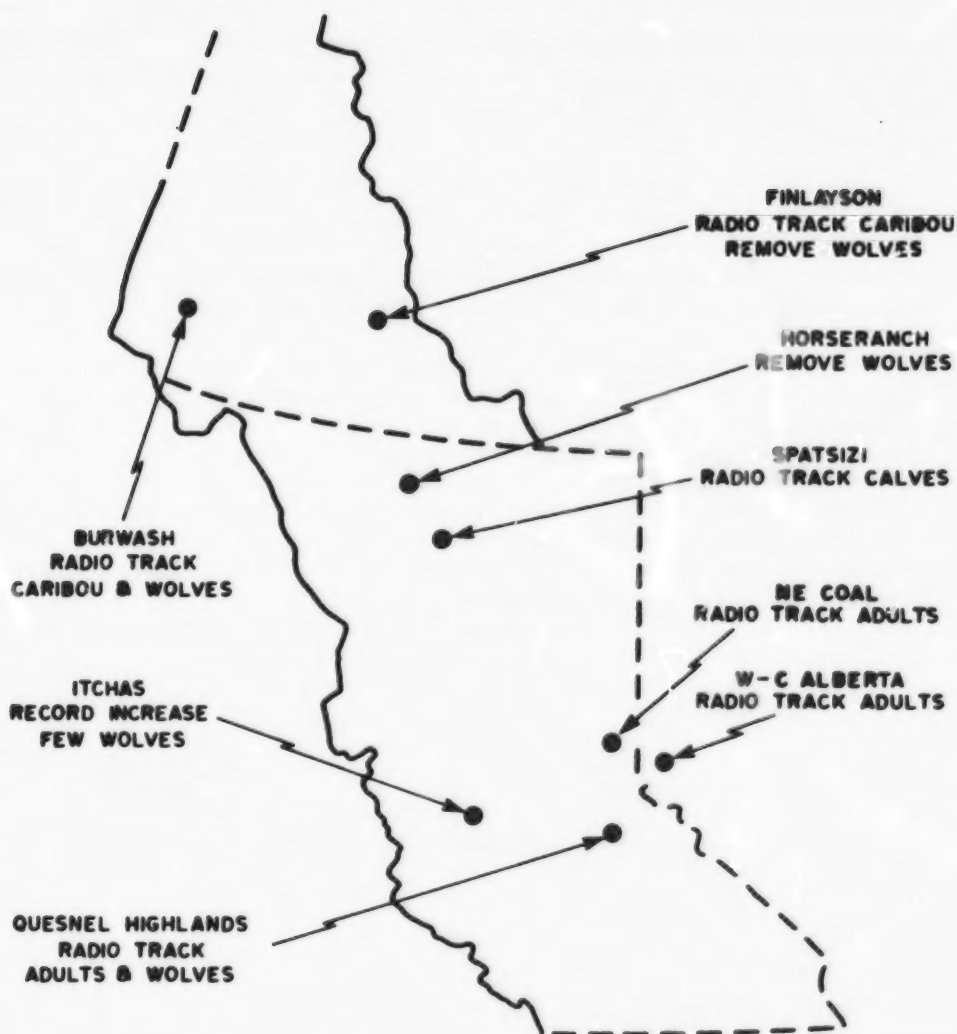


Fig. 2. Study areas of mountain caribou, where predation has been identified as the limiting factor. Types of data gathered listed for each study.

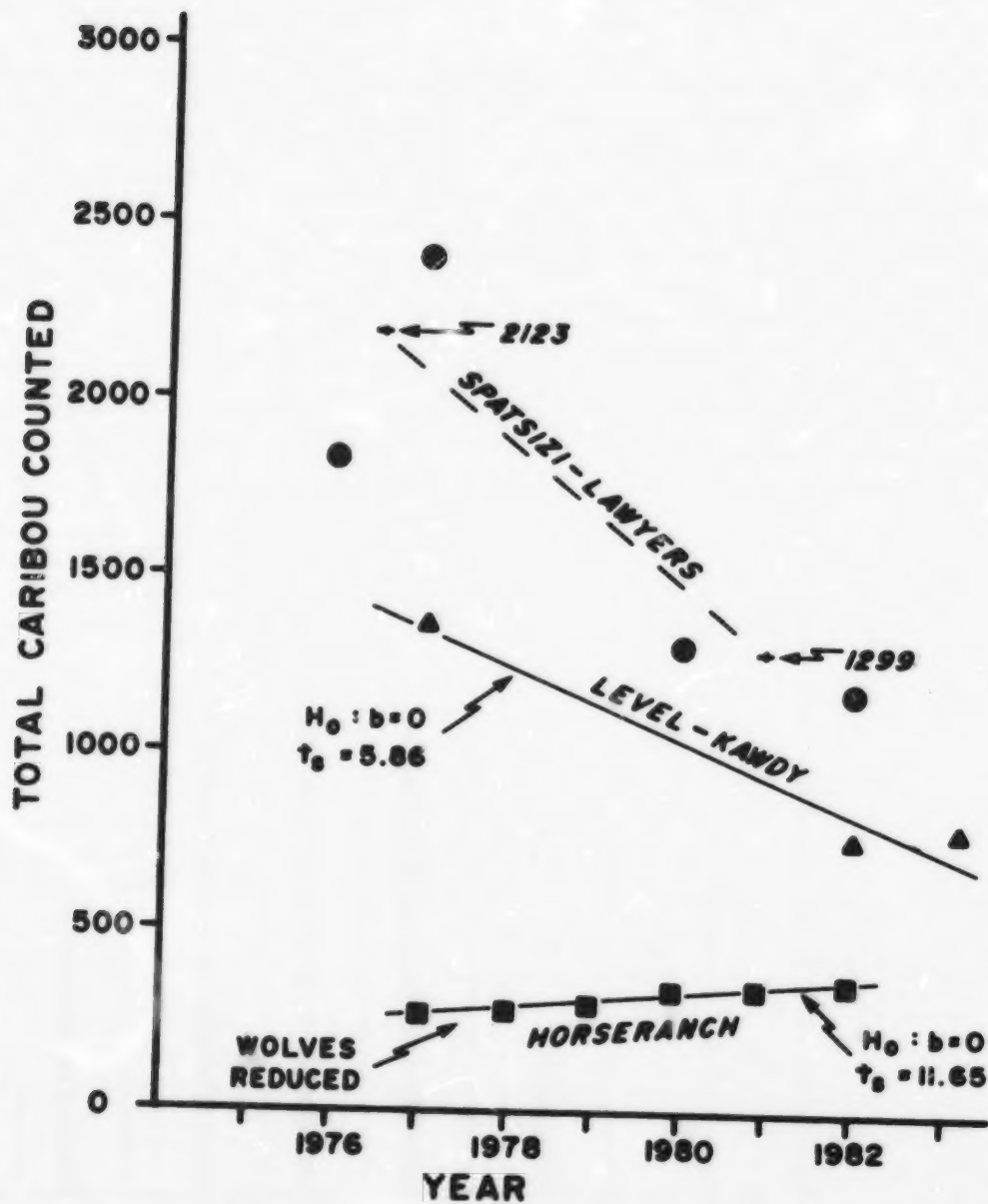


Fig. 3. The decline of the Spatsizi and Level-Kaudy herds without wolf reduction and the increase at Horseranch where wolves were removed.

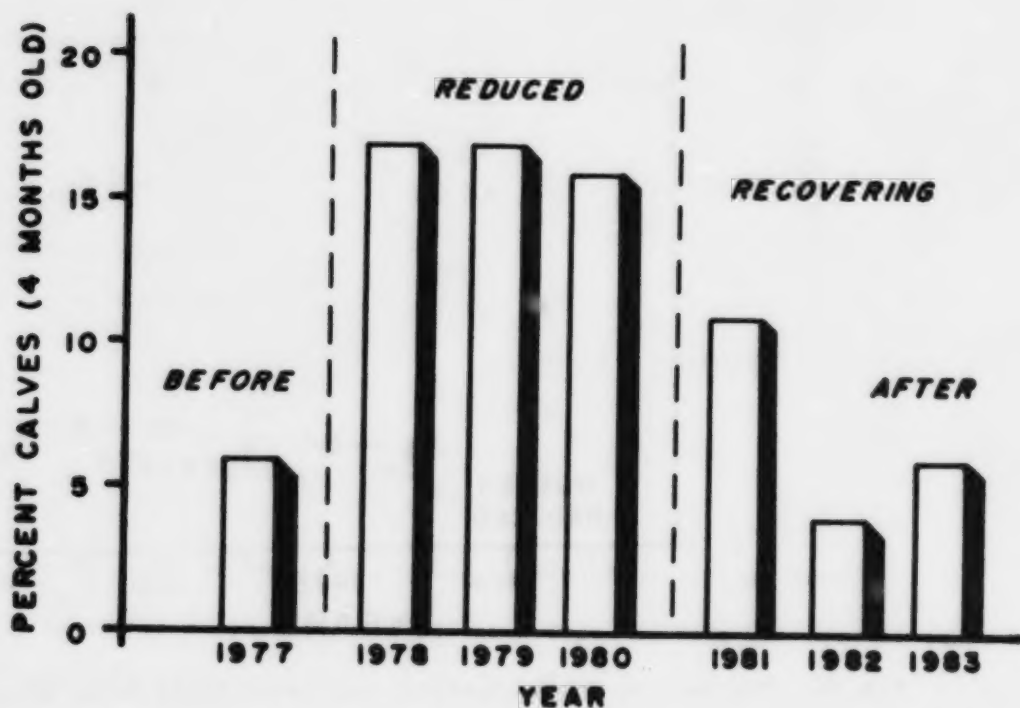
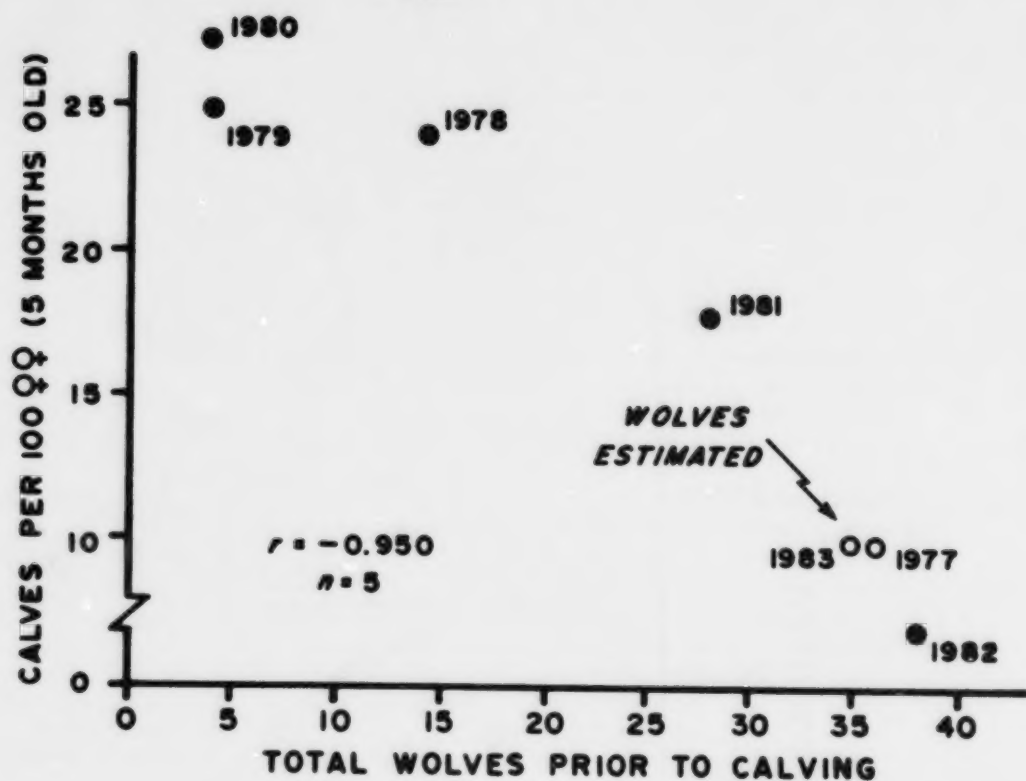


Fig. 4. Calf survival at Horseranch compared to wolf numbers.

counted 310 animals in 1973 and current estimates are about 1,400 (T. Smith, this volume). This is a growth rate of $r = 0.13$. This growth rate is similar to the Western Arctic Herd's and the George River Herd's in the Arctic. All three herds have similar high calf percentages ($\approx 20\%$; Davis and Valkenburg 1985, Luttich pers., Bergerud 1978). Thus I do not agree with Stevenson & Hatler's conclusion that I undercounted the herd in 1973. There were few wolves present in 1973 and few have been seen on recent surveys (two surveys provided by Wildlife Branch, Victoria). Also T. Smith reports that coyotes are common on the herd range; since coyotes don't co-exist in high numbers in the same habitats with high wolf numbers, this is consistent with the hypothesis of low wolf numbers. Thus the positive growth rate of this herd is in turn consistent with the predation hypothesis.

The staff of Renewable Resources radio-tracked six caribou in the Northeast Coal development. Two adults died, probably both from predation. Further, calf survival was low and wolves were observed in the alpine and subalpine habitat of spring and summer range. These workers concluded predation was limiting the growth of the herd (approximately 50 animals) (Sopuck 1985). R.D. Jakimchuk (this volume) felt forage was not limiting and gave a ball-park estimate that the range could support possibly 3,000+ animals.

In the Quesnel Highland, D. Seip and D. Hebert are following both radio-collared females and wolves. To date their studies show a high loss of adults, with the most important cause of death predation. Also calf survival is low. They note that wolves in the winter are mostly in the lowland hunting deer and moose), but move to the alpine when caribou are calving. They report in the first progress report that their results are more consistent with the predation hypothesis than the forage limitation hypothesis.

The survival of calves in the Tweedsmuir herd also provides evidence that predation can be limiting. Poison baits were placed in the park in 1956 and 1957. Stevenson & Hatler (1985:131) state "(Bergerud) alluded to the high calf percentage in Tweedsmuir after this control in 1962-64." I did more than "allude," I reviewed the high percentages documented in the older literature (Bergerud, 1978:36): 29% calves, August 1958; 30% calves, March-April, 1962; 21% calves, January, 1963; 19% calves, Spring, 1964; 11% calves, March-April, 1965. With these percentages and light harvests prior to 1965, the herd had to increase.

In west central Alberta, Edmonds & Bloomfield (1984) conducted an intense study of mountain caribou by radio tracking from 1979 to 1983. Their final statement (p. 143): "Presently, woodland caribou herds in Alberta are not increasing, indeed they appear to be still in decline, with predation being the most likely controlling factor. Caribou numbers will continue to decline, not because of direct loss of habitat ... but because of subsequent changes in the balance of predation-prey relations."

The radio collar studies have finally provided the evidence to convince those people who have open minds that predation, the most consistent limiting

Table 6. 2 x 2 contingency table of interaction of predation and habitat disturbance with examples.

	Predators	
	<u>Cause Present</u> Many wolves	<u>Cause Absent</u> Few or no wolves
<u>Effect Present</u> Habitat Disturbed	Caribou decline, extinction, <u>Quesnel Highlands.</u>	No Decline High unstable population. in absence of hunting, <u>Slate Islands.</u>
<u>Effect Absent</u> No Habitat Disturbed	Low numbers but persist, little hunting, <u>Spatsizi</u>	High numbers, hunting permitted, <u>Ilgachuz-Itchas</u>

factor in the growth of herds. For a population to decline the balance between recruitment and adult mortality ($M = R$ in a stable population) must be altered. The normal manner in which the equation is unbalanced is by an increase in the mortality of calves and/or adults. There is only one common cause of this increased mortality; it is increased predation by natural predators and man. If we want to manage caribou, we must address how to moderate these mortalities in the face of habitat disturbances.

Discussion

Prepleistocene Relics

I disagree with the statement credited to R. Demachi in Stevenson and Hatler (1985) that the caribou in southern British Columbia are prepleistocene relics. Caribou have the widest range in terms of total area (from 47°N to 82°N and across the entire holarctic) of any deer species (cf. Whitehead 1972). By this standard they are the most adaptable cervid. However, numbers decline when moose and deer invade their southern range (Bergerud 1974, 1985). This suggests along with morphological and behavioural parameters (Butler 1986) that they evolved in the North and pushed south and were able to adapt to conditions in southern British Columbia. If climatic changes result in warming trends they may fare badly along the southern edge of their range; however their range is not a relic one but a peripheral distribution resultant from following alpine-conifer ecotypes southward.

Decline of Selkirk Caribou

The caribou of the Selkirks is listed as an endangered species and considerable funds are available for research. The major research need is to determine the cause of the low calf percentages. The statement by Nelson and Baker (1985) that "Many of them [calves] die from exposure" is absolutely without support. Calves are not dying from exposure on the southern edge of their range under tree canopies. They further believe inbreeding may be a problem. Inbreeding depression (Ralls and Ballou 1983, Selander 1983) is a possibility but many animal populations live in small demes which permit them to specialize to their particular environment. Another possibility is that the Selkirk could have disease problems on the southern edge of their range (Bergerud 1983). I believe predation is the most likely cause of low calf survival and the failure to find dead calves. The wolverine (*Gulo gulo*) is the prime suspect. These tough predators travel extensively on the snowpack in spring and also cache food, such as squirrels, that they may revisit in high mountains in spring. Caribou, because of low numbers, would be a secondary prey species.

To resolve the mortality question, all 10 females in the herd should be equipped with radio collars with motion sensors. Since the animals are extremely tame (which seems to preclude the possibility of bear predation) this complete capture seems possible. At calving time each animal could be continuously monitored with Rustrak activity recorders. When an animal goes into labor it could be detected. Births then could be monitored to detect

still births, birth defects, diseased calves. Viable calves would be equipped with mortality mode collars. It would also be valuable to radio track wolverines. The cause of poor calf survival can be determined and should be resolved before the introduction of new genes into the isolated population.

Critical Ranges

All my days as a caribou biologist other biologists have spoken of the critical winter range. Stevenson and Hatler 1985:13 state "... because the caribou winter ranges are regarded as critical". This statement is now accepted as dogma; authors commonly do not even include references. Preservation of the "critical winter range" is the core of the caribou management plans in British Columbia, Manitoba, and Ontario and of the management recommendations of Stevenson and Hatler (1985).

When biologists are more exacting and provide a list of references that are supposed to have documented the essential nature of the winter ranges, they list first of all Edwards 1954. But York Edwards' study does not support the hypothesis at all. Edwards documented a large forest fire mostly on lowland ranges in Wells Gray Park in 1926. However the caribou did not decline until 1935 and after. The caribou became especially scarce after 1945 (review in Stevenson & Hatler 1985). This decrease coincided with an increase in abundance of wolves (review in Bergerud 1978) and a scarcity of the sign of calves. The caribou did not decline coincident with a shortage of food immediate post fire. They declined after deer, moose and predators increased following development of early fire successional stages (cf Edwards 1954). Caribou again increased after 1952 when wolves declined when the new forests would still not have developed arboreal lichens. The sequence documented is that of increased predation, not food shortages and starvation.

At this conference Seip and Hebert report significant predation of caribou in the Quesnel Highlands. In this case the alternative prey reside in logged areas and again as in the case of the 1926 fire, lichen supplies have been reduced by logging. However their analysis of fecal nitrogen in the feces of the Quesnel animals show adequate late winter diet when arboreal lichen are supposed to be in short supply.

When will we get rid of the dogma of critical winter ranges? This is an idea that we inherited from studies in the United States where cervids in the absence of their natural predators did have winter starvation problems. Certainly we cannot continue to quote as our primary evidence of critical winter range a reference that is 30 years old that has no quantified data as evidence.

The Telkwa Herd is a good example of a herd that has persisted and even reached high densities in 1965 after losing its historical winter range. The snow contour maps of British Columbia indicate that this herd in the past would have had to migrate east to the Barine region in winter. They moved to areas of reduced snow as the Tweedsmuir herd now does, by going to the Fawnie Hills. The Telkwa Herd has lost its entire natural winter range and now winters in

ranges in high mountains that formerly were used mostly for calving and summering. Winter ranges per se are not critical. The Telkwa herd persisted because it maintained its critical calving range and predators were not free to move from the lost winter ranges disturbed by humans and cause negative recruitment.

The critical habitat for a pristine caribou herd is not the winter habitat. The critical habitat for a caribou herd with undisturbed habitat is the range where the caribou must meet its natural predators with its highly vulnerable neonates - it is the calving range. However the winter range could become critical if it is so disturbed that it seriously reduces the antipredator strategies (escape in space) that caribou have evolved to cope with predators and thus increase $M > R$.

Conclusions

In the past Ralph Ritcey and I have disagreed on the role of logging in caribou declines. I have held that habitat disturbance can be followed by caribou declines (Bergerud 1974, 1978: Fig 6). But my argument is that the caribou have not declined for nutritional reasons. Part of the argument may be semantic. Ritcey notes that caribou in the winter in southern British Columbia are found in old aged forests with abundant arboreal lichens and that animals abandon former ranges when they are logged. I do not disagree caribou should optimally forage in the absence of predators; but I argue that these small changes in distributions do not necessarily mean the population has declined. Winter ranges are more variable for caribou than at any other season (cf. Kelsall 1968). These range shifts are not the necessary evidence to argue food shortage resulted in inbalancing the recruitment mortality equation ($M = R$). Then the argument is made that when all the habitat is gone the animals will be gone - then it becomes a definition of what is viable habitat and my primary concern is where the caribou must meet their predators with vulnerable young. I believe that long before the food resources become critical, which really seems impossible to me, the caribou will have disappeared not from food shortages but from increased predation and illegal hunting.

Caribou populations decline following habitat disturbances. This generalization is usually true but there are exceptions. It is these exceptions that prove the point. Caribou have increased in Newfoundland in the past 28 years from 5000 to 40000+ (Bergerud 1971, et al. 1984, E. Mercer pers. comm.). This increase has occurred in the face of new road access, extensive logging, and hydro impoundments. In Ontario the State Islands were logged in the 1930's, caribou were common then on the islands and have persisted at high numbers till the present time (Cringan 1956, 1957, Bergerud 1985). In both of these examples wolves were absent from the systems and therein lies the key (Table 6).

We do understand population processes in declines, contrary to the views of Stevenson and Hatler 1985). Populations decline because of increased hunting and expanded predation of calves and adults (Bergerud 1974). Stevenson

and Hatler (1985) offer many habitat recommendations to maintain caribou in central and southern British Columbia but they ignore predator management, the only real tool we have. Their bias seems clear; they give as examples of the regulation of natural populations, studies of deer and elk limited by food, but fail to mention that wolves are now gone from those systems. We need more information on how logging upsets predator-prey interactions. We need to know the limiting factor for wolves. I would welcome the opportunity to study limiting factors of wolf and coyote populations in the Ilgachuz-Itchas. If wolves remain low in that area, caribou can persist despite logging.

We can maintain viable populations of caribou in disturbed habitats, if we are prepared to halt poaching and manage the predators to minimize their impact after we have altered the habitat. Let's give the caribou a break; they have as much right to exist as do wolves and being one step down the food chain are more efficient converters of energy.

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4.3 SAMPLE SIZE CONSIDERATIONS FOR ESTIMATING RECRUITMENT, POPULATION TREND, AND TOTAL NUMBERS OF CARIBOU IN BRITISH COLUMBIA

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Introduction

Gill et al. (1983) described four major periods that big game census in North America passed through during the last 50 years: (1) "Era of Total Enumeration" in which biologists attempted to count total numbers of ungulates comprising the most important herds; (2) "Era of Trend Indices" where trend counts replaced estimates of population size; (3) "Era of Simulation Modelling" in which simple population models were used to simulate population dynamics and estimate total population size; and (4) "Era of Sample-Based Estimates of Population Size" where aerial survey methodology was combined with sampling theory to provide estimates of population size with associated levels of precision.

To some extent, caribou population inventory in British Columbia has followed a similar evolution, although today all four approaches are still in use. Attempts at total enumeration was started in the early 1960's with counts conducted during periods when caribou were most concentrated and easily visible. For many northern caribou herds, this is during the rutting period when animals are concentrated in open areas above treeline. Other herds, such as the Telkwa Range in north-central British Columbia have been counted in late winter-early spring (Theberge and Oosenbrug 1977). The Pink Mountain herd in northeastern British Columbia has been counted in December (Bergerud 1978). In southern British Columbia, total counts have been attempted during July when caribou are often concentrated on snow patches above treeline (Ritcey 1976) or during post-calving when large aggregations of caribou are present above treeline (Hebert pers. comm.). The central assumption in these surveys is that all of the animals are counted (total count) or a constant proportion is seen during each survey (trend count). Preliminary tests using radio-collared animals suggests neither assumption may be true (Hatter in prep, Hebert pers. comm.).

Following recommendations by Bergerud (1978), increased emphasis has been placed on measuring caribou recruitment (% calves of the herd in October) over the last 8 years. Bergerud (op cit) provided a correlation between recruitment and natural mortality that could be used to estimate adult natural mortality rates. In the absence of hunting, or with an estimate of population size or harvest rate, the finite rate of increase could also be estimated (Bergerud and Hatter in prep). Attempts to use this method have been restricted by the uncertainty in the estimates of natural mortality. Also recruitment is typically measured in

October, rather than prior to calving, which requires the use of correction factors to account for overwinter calf mortality.

Simulation modelling of caribou populations was explored with various computer programs such as Pop I (Gross 1970), Pop II (Bartholow 1981), Ungulate (Stevenson in prep), and other simple population models which utilized the mortality-recruitment relationships described by Bergerud (Elliot et al. in prep.). As found elsewhere in North America, the most significant outcome of these activities has been to reinforce the need for accurate and precise inventory data.

Sample-based estimates for recruitment, population trends and total numbers are presently being developed for caribou in British Columbia. These include sampling for calf proportions in Spatsizi Park (Jones this vol.), replicate surveys for measuring reliability of population trends in the Itchas-Ilgatchuz Range (Hebert pers. comm.), and mark-recapture for estimating total numbers in Spatsizi (Hatler pers. comm.) and the Itchas-Ilgatchuz (Hebert pers. comm.).

In this paper I outline the advantages of sample-based estimates, provide standards for survey precision and accuracy, indicate how present procedures can be modified to provide sample-based estimates, and provide formulas for estimating sample size. A series of programs for calculating estimates, confidence limits and sample sizes on a portable microcomputer are described in the Appendix. This paper does not address regional aspects of caribou inventory such as survey timing, flight considerations etc., which must be understood before a sampling design can be developed.

Why Sample-Based Estimates

Some major advantages of sample-based estimates over total counts and trend indices are (Caughley 1977): 1) samples are often more efficient and cost-effective than total counts; 2) sample-based estimates allow calculation of the population variance which can be used to place confidence limits on the estimates; 3) differences in population numbers or composition over time and space can be tested statistically; 4) sampling greatly reduces the chance of counting some individuals more than once and missing others completely; and 5) the population is less disturbed by the census.

Definition of Terms

The application of sample-based estimates in population inventory must consider questions of accuracy, bias, precision, frequency, and resolution. These concepts are defined below (White et al. 1982, Gill et al. 1983):

ACCURACY: Accuracy refers to the difference between the estimate and the population parameter (eg. calf proportion, population size). Usually the accuracy of a survey is not known and can only be evaluated by estimating bias and precision from samples, ie. accurate estimation procedures are those which

have small biases and good precision.

BIAS: Bias can be classified into 2 types: 1) small-sample biases; and 2) model bias. Model bias is the most serious of the two since increasing sample size usually does not reduce the magnitude of the bias. All sample-based estimates are based on statistical models which depend on one or more assumptions. If not all of the assumptions of the statistical model are met, model bias results. For example the use of mark-recapture for estimating caribou numbers depends on 6 major assumptions. Violation of any one of these assumptions will result in a biased estimate, regardless of sample size.

PRECISION: Precision relates to the repeatability of the result. It can be quantified by the sampling variance and improved by increasing sample size, by employing alternative sampling strategies, or both. Typically, precision is indicated by associating confidence limits with the estimate. For caribou, we can measure precision of trend counts by replicating surveys.

RESOLUTION: Resolution refers to the degree or extent to which we want samples to apply. That is, for caribou, should the data apply to caribou on a rutting range (Bergerud 1978) or those individuals that share a common winter range (Hatler this vol.)?

FREQUENCY: Frequency refers to how often the census is repeated. For caribou, herds such as Spatsizi and the Itchas-Ilgatchus are censused annually. The Wells Gray herd is censused at 3-5 year intervals. Generally, herds that are increasing or declining rapidly need to be censused more frequently than more stationary herds. Similarly, herds with less precise survey data require longer sampling periods before reliable trend lines can be established (Harris 1986).

Levels of Precision and Accuracy for Sample-Based Surveys

Most sample size formulas require a preliminary estimate of the population parameter and its standard error, as well as an allowable error (e) of the estimate (eg $\pm 10\%$), and a desired probability level of the estimate following within the specified range. Thus, for example, we might ask what sample size do we need to estimate the number of caribou within $\pm 10\%$ of the actual number with 90 % confidence limits. Table 1 provides suggested guidelines for precision and allowable error in sample-based surveys, depending on the intended use.

Table 1. Levels of precision and allowable error for sample-based surveys

LEVEL	CONFIDENCE LEVEL	ALLOWABLE ERROR	INTENDED USE
1	90 %	+/- 10 %	- Inventory Development
2	90 %	+/- 25 %	- Population Research
3	90 %	+/- 50 %	- Intensive Management (Key Ungulate Areas)
			- Less Intensive Management

Sample Size Considerations for Estimating Recruitment

Consideration of sample size for estimating recruitment is dependent on which sampling plan is used. The most popular method treats individual animals as the sampling unit and assumes that individuals are independently and randomly sampled from the population (Czaplewski et al. 1983). An alternate approach is to use cluster sampling which treats groups of animals as the sampling unit (Samuel 1984). This approach assumes groups are independently and randomly sampled from the population. Ramey (1984) indicated there was a negative exponential relationship between the proportion of caribou calves per group and group size. This suggests cluster sampling may be more appropriate than simple random sampling of individuals for estimating recruitment. Table 2 contrasts the formula for estimating sample sizes for caribou recruitment.

Table 2. Sample size formula for estimating caribou recruitment.

SIMPLE RANDOM SAMPLING OF INDIVIDUALS (from Czaplewski et al. 1983)

$$n = \frac{Nt^2 pq}{e^2 (N-1) + t^2 pq}$$

where: n= no. of caribou in sample
a= no. of calves in sample
p= proportion of calves in sample (p= a/n)
q= 1-p
N= estimated population size
t= t value
e= allowable error (+/- proportion of p)

CLUSTER SAMPLING (from Scheaffer et al. 1979)

$$n = \frac{N s^2}{ND + s^2}$$

$$s^2 = \frac{\sum_{i=1}^n (a_i - \bar{a})^2}{n-1}$$

$$D = \frac{e^2}{t}$$

$$\bar{m} = \frac{\sum_{i=1}^n m_i}{n}$$

where n = no. of caribou groups
m = no. of caribou in a group

A problem with using either of these formulas is that an estimate of calf recruitment and herd size is required to estimate the sample size. For cluster sampling, the variance must also be estimated. If these parameters are poorly estimated, then the resulting sample size calculations will also be in error. An alternative to estimating sample size is to continue sampling until confidence limits fail to become notably smaller or a desired level of precision is reached. This can be achieved by periodically recalculating confidence limits as a survey proceeds with a portable microcomputer.

Of considerable interest is determining the sample size needed to compare two recruitment rates. Table 3 provides the sample size equation to test for a significant difference between two calf percentages. An example might be testing for increases in caribou recruitment following wolf control.

Table 3. Sample size requirements for comparing two recruitment rates (from Snedecor and Cochran 1967).

$$n = \frac{(Z_a + Z_b)^2 (p_1 q_1 + p_2 q_2)}{(p_1 - p_2)^2}$$

where: Z_a = normal deviate corresponding to significance level
 Z_b = normal deviate corresponding to the two-tailed probability
 p_1 = proportion of calves in first sample
 q_1 = $1-p_1$
 p_2 = proportion of calves in second sample
 q_2 = $1-p_2$

Sample Size Considerations for Estimating Population Trend

Two approaches have been used to monitor caribou population trends in British Columbia. The first uses recruitment rates and calculates adult mortality by the following equation (Bergerud 1978):

$$M = 13.8 - .3865(R)$$

where: M = yearling and adult mortality rate (%)
 R = recruitment rate (% calves at 12 months of age)

The finite rate of increase (L) is calculated as (Bergerud and Hatter in prep):

$$L = \frac{(100-M)}{(100-R)}$$

and the annual percent change as

$$\% \text{ Change} = (L-1) \times 100$$

The second approach is to conduct two or more annual counts, assuming a constant fraction is observed each year. The exponential rate of increase (r) is calculated by regressing $\ln N$ for each estimate against time in years. The slope of the regression line is r (Caughley and Birch 1971). The finite rate of increase is calculated from r as:

$$L = e^r \text{ where } e \text{ is the base of natural logs (2.71828)}$$

Neither approach, however, allows for error in the estimates and is not directly amenable to sample size calculations. An alternative is to conduct replicate within year counts for two

or more years. The mean and variance can be calculated for each year to test whether a statistical difference exists and hence determine if the herd has increased, remained stable (no significant difference) or declined. Since total counts for caribou are essentially indices to population numbers, sample size formulas for indices can be used (Eberhardt 1978). Table 4 indicates one formula that avoids estimating the mean and variance by using the coefficient of variation (CV). Replicate surveys can be used to provide an estimate of CV.

Table 4. Sample size formula for estimating the number of replicate surveys (from Eberhardt 1978).

$$n = \frac{t^2}{e^2} \times CV^2$$

where t = t value
 CV = coefficient of variation
 e = allowable error (prop. of mean)

If one has a reasonably good idea of the CV it is possible to judge roughly what kinds of differences between two populations will be significant. Table 5 shows the sample size formula, assuming the CV remains roughly constant for the two populations.

Table 5. Sample size formula for comparing two populations from replicate total count surveys (from Eberhardt 1978).

$$n = \frac{2 \times (t_a^2 + t_b^2) \times CV^2}{(k - 1)}$$

where t_a = t value for a Type I error
 t_b = t value for a Type II error
 CV = coefficient of variation
 k = multiple of the first mean

Recently, Harris (1986) provided an equation to determine the number of within year replicate counts to measure the rate of increase (r) to within 0.05 at the 68% confidence level. The number of years must be specified and the coefficient of variation from replicated counts estimated (Table 6).

Table 6. Sample size formula for estimating the number of replicate surveys to measure the population rate of increase (from Harris 1986).

$$n = \frac{12 (SD)^2}{k (k-1) [SE(r)]^2}$$

where: $SD^2 = \ln(1 + CV^2)$
 CV = coefficient of variation
 k = no. of years over which r is to be estimated
 $SE(r)$ = desired level of precision
 $= [(12 (SD)^2) / nk (k-1)]^{0.5}$

Sample Size Considerations for Estimating Population Size

Present attempts at determining population size from sample-based estimates in British Columbia have been restricted to mark-recapture (Hebert pers. comm.). This approach is ideally suited to caribou which concentrate in open habitats. For situations where caribou do not concentrate above treeline, sample block surveys may be preferable (Siniff and Skoog 1964, Gasaway et al. 1986).

Single Mark-Recapture

In single mark-recapture the estimate of N , the number of caribou in the population, requires a sample of M caribou be marked for future identification, and then returned to the population. After allowing time for marked and unmarked to mix a second sample of n caribou are taken and the number of marked animals m noted. Several models are available for estimating N from single mark-recapture. For caribou, Chapman's unbiased estimate (Chapman 1951) is probably the most suitable model:

$$N = \frac{(M+1)(n+1)}{(m+1)} - 1$$

The Chapman estimate becomes exactly unbiased when $n+M > N$. The bias of the estimate also becomes negligible as $n \times M$ exceeds N by a factor of 4 (Robson and Regier 1964). The use of single mark-recapture requires the following assumptions (Seber 1973): 1) the population is closed (N is constant) or marked and unmarked animals die or leave the area at the same rate; 2) all animals have the same probability of being caught in the first sample; 3) marking does not affect the catchability of the animals; 4) the second sample is a simple random sample (any marked animal has the same chance of being captured as an unmarked one in the second sample); 5) animals do not lose their marks in time between the 2 samples; 6) all marks are reported on recovery in the second sample. The use of radio-collared animals helps to ensure that assumptions 1, 5 and

6 are met. Table 7 indicates the sample size formula for single mark-recapture, providing $N > 100$ and $m > 40$.

Table 7. Sample size requirements for number of caribou marked and sampled using single mark-recapture (from Robson and Regier 1964).

$$D = \frac{n \times m \times (N-1)}{(N-n) \times (N-m)}$$

where: n = no. of caribou in sample
 m = no. marked caribou in sample
 N = estimated no. of caribou
 M = no. of marked caribou

Confidence Interval	Allowable Error	Value of D
75	50	4.75
90	50	14.8
90	25	45.5
95	50	24.4
95	25	69.9
95	10	392.0

Values of n , m and N are substituted into the above equation which satisfy the value of D . Robson and Regier (1964) provide graphs for estimating n and m , based on 95% confidence limits and allowable errors of 50%, 25%, and 10%. As an approximation to the above, one can use the coefficient of variation of the population estimate as (Seber 1973):

$$CV = \frac{1}{0.5 [(nM/N)]}$$

When the desired coefficient of variation is put into the above equation and a reasonable guess at N is attempted, some idea may be obtained of the effects of different sample sizes in first and second samples. Because nM/N is the expected number of recaptures (m), it is also possible to use the equation to obtain a notion of the number of such individuals that must be obtained in the second sample. One can then continue until a prearranged number of marked animals is observed, obtaining approximately the same coefficient of variation as indicated above (Seber 1973).

Multiple Mark-Recapture

Multiple mark-recapture is preferable to single mark-recapture. By replicating total counts of caribou with marked individuals, large values of n/N can be obtained which reduces the required

value of m/n to a range practical for management. This enables much more precise estimates to be obtained than is possible with single mark-recapture. As with single mark-recapture, several models are available. The modified Peterson estimate (Rice and Harder 1977) is probably most suitable for caribou. The Chapman unbiased estimate is calculated from each sample with the final estimate set equal to the average of the individual estimates. Two additional assumptions required are: (7) the population remains constant over the sampling period; and (8) aerial surveys are independent. Rice and Harder (1977) provide graphs for calculating sample sizes with 95% confidence limits and an allowable error of 10%. If the approximate costs of marking and sampling caribou are known, the graphs can also be used to answer 2 other important questions: (1) which combination of marking and sampling effort will give the desired expected confidence interval size for the lower cost; and (2) which combination of marking and sampling effort will produce the tightest expected confidence interval for a fixed census budget. For most situations with caribou in B.C. only 2 or 3 samples will be possible (Hebert pers. comm.). However, even a few samples can greatly increase precision over single mark-recapture.

Sample Block

Although sample block surveys have been conducted for caribou (Siniff and Skoog 1964), they have not been attempted in British Columbia. Both simple and stratified random block surveys have potential for caribou census. Table 8 indicates the sample size formula for the number of blocks to be surveyed depending on whether the population is randomly or contagiously distributed.

Table 8. Sample size formula for estimating the number of sample blocks based on simple random sampling (from Sen 1983).

POPULATION RANDOMLY DISTRIBUTED

$$n = \frac{S^2}{1 + NCV^2}$$

where: n = no. of sample blocks (equal or unequal sized blocks)
 S = total no. of blocks
 N = estimated population size
 CV = coefficient of variation

POPULATION CONTAGIOUSLY DISTRIBUTED

$$n = \frac{1}{CV^2} (S/N + 1/k)$$

where: k = parameter of the distribution and $k > 0$

An alternative to the above is to plot the confidence limits (as a percentage of the estimate) against the number of blocks surveyed. The point at which the curve tends to flatten out represents the most cost-effective sample size, with further increases in sample size producing negligible reductions in sample error (Norton-Griffiths 1978).

For contagiously distributed populations, stratification may be used so that animals are randomly distributed within each strata. Table 9 indicates the sample size formula.

Table 9. Sample size formula for estimating the number of sample blocks based on stratified random sampling (from Seber 1973).

$$p = \frac{\left(\sum_i [(N A_i)^{0.5}]^2 \right)}{AN(1+NCV^2)}$$

$$n = \frac{S}{p}$$

where N= estimated population size
A= area
i= no. of strata
p= prop. of area sampled
CV= coefficient of variation

For a fixed census budget, sampling should be distributed optimally amongst the strata to obtain the most precise estimate for the dollar. This is achieved by calculating a relative variation factor (RVF) in each stratum (Gasaway et al 1986):

$$RVF = \frac{A}{x} \times [(s)^2]^{0.5}$$

where s is the sample variance of the stratum, A is the stratum area and x is the mean area of blocks surveyed in the stratum. Table 10 provides the formula for optimal allocation among strata.

Table 10. Formula for optimally allocating sampling effort amongst 3 strata in a stratified random block survey (from Gasaway et al. 1984).

$$n = \frac{RVF_m}{RVF_l} \times n_l$$

$$n = \frac{RVF_h}{RVF_l} \times n_l$$

$$n = \frac{RVF_h}{RVF_m} \times n_m$$

where n_i = no. of blocks to be searched in each stratum.

RVF_i = relative variation factor in each stratum.

Conclusions

The objective of this paper has been to provide some guidelines for estimating sample size for recruitment, population trend and total numbers in caribou. The approach has been largely orientated towards estimating sample size from formulas that require an estimate of the parameter and its variance. In actual field application, this rarely happens. Rather sample sizes are usually fixed by inventory budgets and no estimate of the parameter or its variance is available. Consequently, the main application of these formulas in caribou inventory will likely be to indicate what kind of precision might be afforded for a specified cost. Eberhardt (1978) notes that in this situation, sampling to obtain desired confidence limits may be less helpful than sampling to test for significant differences between two population parameters. Objectives of the survey must therefore be clearly stated. For example, sampling for a prescribed level of precision may be appropriate for population monitoring. However, if a specified management action is expected to produce a change in numbers then sample sizes should be based on detecting a significant difference. In either case, if the sample size calculations indicate unrealistic sample sizes, then alternative sampling strategies, or utilizing a variety of sources of information should be explored. More research into developing accurate, cost-effective census methodology is still required for caribou in British Columbia.

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Appendix 1

Programs available for calculating estimates, confidence limits, and sample sizes on a Radio-Shack Model 100 portable computer (listings available from author on request).

CLUST.BA - calculates population age/sex proportions, confidence limits, and sample size with groups of animals treated as the sampling unit.

COMPOP.BA - calculates sample size (no. surveys), based on the coefficient of variation of replicated surveys.

COMREC.BA - calculates sample size (no. individual animals) required to determine a significant difference in two population proportions.

HATRND.BA - calculates the precision of a trend estimate, and the number of within year replicate counts required for a stated number of years and coefficient of variation.

MULTMR.BA - calculates population size and confidence limits for multiple mark-recapture models (Modified Peterson Estimate, Schnabel's Estimate, and Schumacher's Estimate).

PCT-CL.BA - calculates population age/sex proportions, confidence limits, and sample size with the individual animal treated as the sampling unit.

POPCHA.BA - estimates the required precision of the second survey (variance), when the first survey is completed, using stratified random sampling.

RAT-CL.BA - calculates population age/sex ratios, confidence limits, and sample size with the individual animal treated as the sampling unit.

REPLTC.BA - calculates sample size (no. surveys), based on the coefficient of variation of replicated surveys.

SINGMR.BA - calculates population size and confidence limits for single mark-recapture models (Peterson Estimate, Chapman's Unbiased Estimate, and Bailey's Estimate).

STRBK1.BA - calculates population size and confidence limits for simple or stratified random block surveys, with or without a sightability correction factor.

STRBK2.BA - same as STRBK1.BA but also calculates population ratios and confidence limits.

4.4 SURVIVAL ANALYSIS FROM RADIO TELEMETRY DATA

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Abstract

The survival of individual radio collared caribou can be extrapolated to population survival rates using many techniques. The differences between rates can be compared according to the risk factors of the populations and used to help explain caribou declines or limitation. Techniques vary in complexity from analysis of proportions alive and logarithmic transformation for linear regression to dedicated programs using numerical maximum likelihood and complicated models of risk factors. The involved methods provide statistically rigorous means to combine data from many independent studies to determine the risk factors of caribou throughout the province.

Introduction

It is relevant to any wildlife management program to determine survival and mortality rates since excessive mortality may prevent a population from responding to other management manipulations. Habitat enhancement or harvest restrictions might not benefit a population that is limited by other mortality factors.

This workshop has highlighted an opportunity to easily gain valuable insight into caribou mortality patterns across the province by analysis of the causes of death of animals that have been radio collared for purposes other than mortality estimation. A minimum of 250 caribou have been collared in Western Canada. Animals, especially young, are often radio collared for the explicit purpose of estimating the contribution of various causal factors to low survival. These studies tend to have large samples of collared animals well-distributed across the various categories of mortality risks with intensive and frequent monitoring and so these data are relatively easily analysed. This paper attempts to identify techniques that we can use when sample sizes are small, specific cause of death is unknown, and frequency of relocation is variable. The relative frequency of death can be apportioned to the potential risk factors (ie. predator density, intensity of logging, ease of access, habitat disruption and human activity).

Risk Factors

The first step in an ad hoc analysis such as this must be to identify the risk factors. In medical analogy, this is not just the cause of death (eg. cancer), but the causal relationships that may also have predisposed the individual to a premature failure (eg. smoking, radiation, diet). This requires a substantial understanding of the biology of the animal, tempered with a healthy degree of logic and insight. The proximate cause of death of a caribou might be predation, but the animal may have been predisposed to its fate by a virulent disease, severe weather, or a host of other factors. It may be insufficient to identify the predator as the main mortality factor without identifying the antecedent risks.

It has been reported that caribou populations decline after logging (Bergerud 1978, Stevenson and Hatler 1985, Ritcey this vol.), that logging is a risk factor in the environment of caribou. There are seven causal relationships that have been identified as detrimental to caribou populations.

Logging could:

1. Reduce arboreal lichen abundance.

Caribou in the eastern B. C. mountains appear to be entirely dependent on arboreal lichens for winter survival (Antifeau this vol., Simpson this vol.). In this respect, they may be unique in the world. Logging reduces or eliminates arboreal lichen and so might reduce the winter range capacity for caribou.

2. Alter terrestrial forage abundance.

Logging has profound impacts on the historic plant communities. Caribou feed extensively on terrestrial lichens, herbs and shrubs; all are altered in abundance by logging. Additionally, changes in the canopy may subsequently change snow deposition and reduce the availability, if not the actual abundance, of ground forage.

3. Increase vulnerability of caribou to predators.

Caribou have adapted a strategy of avoidance in dealing with their major predator, the wolf. They make extensive and unpredictable movements to prevent any territorial wolves from becoming a constant threat. They calve and winter at high elevations where wolves are less willing to hunt, and are less successful in locating caribou (Bergerud and Page in press).

If logging forces caribou into predictable travel routes, or small blocks of residual habitat, encounter rates with wolves could increase. If high elevation habitats are no longer available, vulnerability (especially of calves) will increase.

4. Increase other wolf prey and increase caribou predation rates.

Moose and deer have increased greatly due to man's alteration of the primeval forest. In B. C., the introduction of moose may have been exceedingly detrimental to caribou populations, as it has been in eastern North America (Bergerud 1974). The strategy of caribou to move extensively and avoid resident wolves only works if the wolf packs have little alternative prey to survive on while caribou are absent.

5. Increase loss to human hunters (legal and illegal).

As with wolves, caribou have essentially only one strategy to avoid human predators - to stay as far away as possible in time and space. Logging roads dramatically increase the access of humans to caribou range. Once exposed, caribou are very vulnerable to the gun, even in forested habitats.

6. Increase human disturbance.

Caribou have been considered wilderness animals, and as such, unable to tolerate disturbance (Gunn and Miller 1979). Logging activity and subsequent access of hunting and recreating humans might be responsible for reduced viability of individuals and eventual decline of caribou populations.

7. Cause shifts in distribution.

Caribou are very mobile and frequently use alternative ranges. Logging could reduce the availability of a required habitat that would eliminate an entire range from use. Disturbance could also cause a shift in the areas used by caribou.

The original risk is only exposure to logging, but increased exposure to predators and humans may also result. The potential interactions are great. For instance, consider a situation where logging occurred in a previously mature forested valley and the resultant seral vegetation favoured a tremendous increase in the local moose population. Wolves would increase with this new prey base but wintering caribou may still be safe in a mountain refuge protected by a barrier of deep, soft snow that wolves could not cross. The seemingly inconsequential act of allowing snowmobiles on the mountain could provide travel routes for the wolves and cause increased mortality for caribou. These interactions must be addressed to properly understand the management actions required to prevent caribou declines.

Statistical Distribution of Survival Data

Survival data is inherently binomial. An animal either lives or dies with no partial outcomes possible. The binomial distribution is unusual in that the variance and mean are a simple function of the sample size and probabilities. The variance is determined by multiplying the probability of living (p), the probability of dying (q which is $1-p$), and the sample size (n) (i.e. $\text{var} = npq$) and the mean is the sample size multiplied by the probability of living ($\text{mean} = np$).

The lack of homogeneity of variance is a problem for analyses that assume normality. With large samples, an analysis may still be valid but samples of 50 in each cell (each year or mortality class) are probably necessary. Logarithmic or arcsin transformations may help to normalize the distribution. The logit-link function is valid to normalize the binomial (where $\text{logit}[p] = \log[p/(1-p)]$) and has been used to identify risk factors for red deer calf survival (Albon et al. in press).

Mortality Rates Constant

In the ideal situation of a study specifically oriented towards estimation of mortality factors, some very simple techniques can be used. In the extreme case, the number alive at the end of the study can be divided by the number collared to determine the proportional survival. Two or more such proportions can be compared using a G-test. This test is not very powerful and may not detect differences that truly exist but it makes no assumptions about normality of data. The animals must all be collared at the same time.

If mortality truly is constant throughout the study period, a logarithmic transformation of % survival will linearize the data, with the slope of a regression line proportional to the rate of mortality. Investigation of the

residuals will indicate any trends in deviation from constant mortality. Since the data are partially correlated (there can never be more animals present at later times), the mortality estimate cannot be considered reliable unless the correlation of the regression is close to 90%. All the assumptions of linear regression apply.

Differences in mortality between years or study areas can be assessed by an F-test of the hypothesis that the slopes of the lines of individual samples are the same. This analysis was used for calf survival data (Page 1985) (Figure 1).

Mortality Different Between Seasons

Mortality rates may be constant within a season, but the study period may span many seasons. The collared animals could be partitioned by season and the previous analysis performed, but programs are available to estimate multiple rates with no implausible assumptions of normality and no small sample biases. A popular program written exclusively for mortality estimation from radio telemetry data is MICROMORT (Heisey and Fuller 1985). Rather than the usual least squares regression techniques, this and most of the subsequent analyses use maximum likelihood methods to estimate the rates and variances. This is irrelevant to the user except when it comes to the interpretation of the output. It is not simply a matter of looking at a significance level for a risk factor to determine whether it is important as in linear regression or analysis of variance. Maximum likelihood output must be interpreted as a comparison of competing models where parsimony rules. This premise is that the simplest explanation is the best, and so with a statistical model. The MICROMORT users guide explains how to calculate the chi-square or F value from its output tables, to test between 2 models or to test between seasonal rates within a single model. MICROMORT weights seasons (periods) equally in calculating overall (span) mortality rates which may introduce some unwanted bias if the number of animals varied greatly between time periods. Mortality estimates cannot be weighted.

MICROMORT cannot deal with missing cells, or combinations of factors with no collared animals. For example, you could not determine mortality rates by sex and season if there were no males alive and collared in winter. It also cannot deal with interactions of factors or multiple classes of animals. A more advanced method called SURVIVE can handle all the analyses that MICROMORT is capable of, plus the approved method for bird-banding analysis (Brownie *et al.* 1978), unbiased life table analysis and general survival modelling (White 1983). The program will perform the tests between competing models itself, including interactions. SURVIVE can also simulate results a priori to determine the sample sizes necessary to distinguish between different survival rates. The simulations will help to allocate effort by determining if it is better to collar many animals for a few years, or a few animals in many years. As an example, I simulated a 5 year study in 2 areas. In one area, the true survival rate was 90% and 80% in the second. If 100 animals were collared in each area

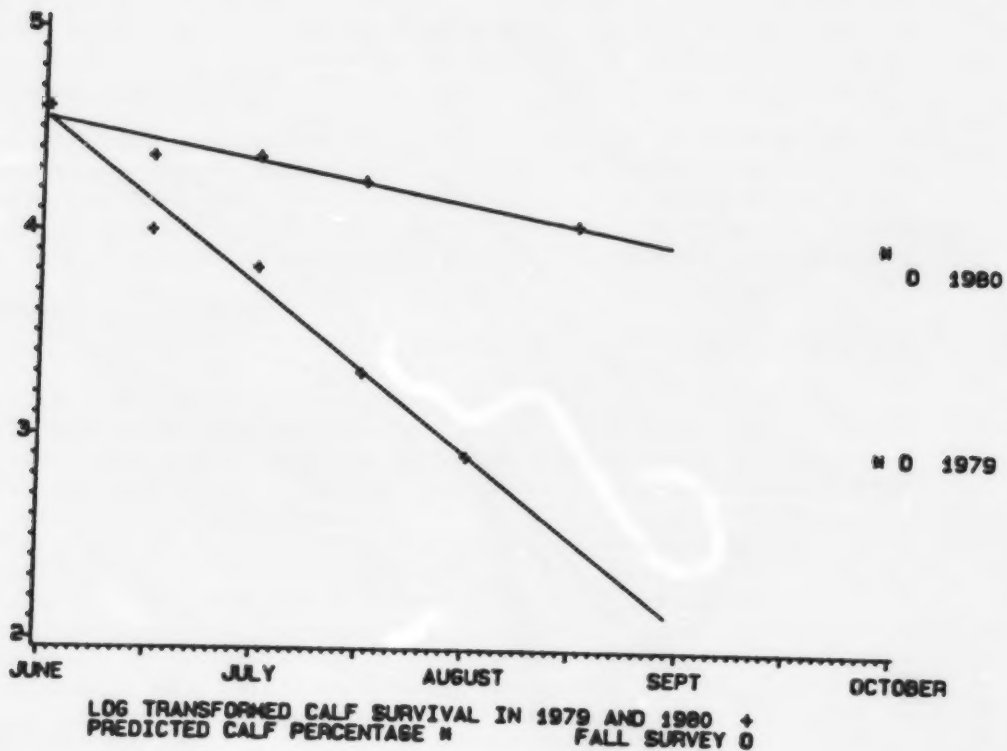


Figure 1. Logarithmic survivorship curves of collared calves.

and monitored for 5 years, this difference in mortality would be detected 100% of the time. If only 20 animals were collared in each area, 41 times out of 100 no difference would be detected at a probability level of .90 (56 times at .95) (Table 1).

The problem is that determining the appropriate model and programming it is an extensive exercise in logic and mathematics. There are no defaults (but there are examples for the simulations). Gary White has volunteered to help anyone who wants to use the program and will develop most models. I can construct any telemetry models necessary and should be able to handle most life table problems.

Mortality Different Between Areas

The previous discussion about mortality different between seasons applies to areas, but there are some additional techniques available. For Isle Royale moose age structure data, I departed from the normal life table analysis and used a modification of a non-linear method proposed by Siler (1980). Remains of more than 1900 moose, collected during summer hiking and winter flying from 1958 to 1985, adequately sampled the age structure of cohorts from 1956 to 1976 (though cohorts from 1946 to 1984 were represented). Large mammals exhibit 2 stages of mortality. An initial juvenile period exhibits very high but progressively declining mortality, followed by a second period of senescence characterized by increasing mortality (Siler 1980). The juvenile period ends on Isle Royale after 2 years, but senescence begins almost immediately. This can be modelled by non-linear estimation of a geometric juvenile mortality followed by adult mortality represented by a logistic decline process (Siler used Gompertz equations for both but geometric and logistic is easier and fits better) identical in technique to the previously mentioned red deer work. I have the model available in BASIC which can be run on the Radio Shack Model 100 and APPLE but is most efficient in compiled BASIC on the IBM PC.

Again, hypothesis tests of competing models representing differences between years (cohorts or areas) can be constructed using an F-test of the residuals from the model output. Isle Royale moose cohorts fell into 5 distinct groups characterized by combinations of high or low, juvenile or adult mortality (Figure 2). The number of moose collected in any one year for any one age class was small (less than 10) but the long data period provided sufficient information to fit the model with accuracy of more than 98%. Hunter samples or ages from captured animals could provide similar results. Some of the assumptions for normal life table analysis apply (Caughley 1966).

An alternative method has been suggested by Wendy Bergerud (MOF, Biometrics Section), using logistic regression (no relation to non-linear regression of the logistic equation). The survival of animals is related to factors in the environment or area. Extremely complicated models can be constructed involving full interaction terms. Wendy has a manuscript that demonstrates the analysis of survival of caribou calves in areas of different wolf density and how to

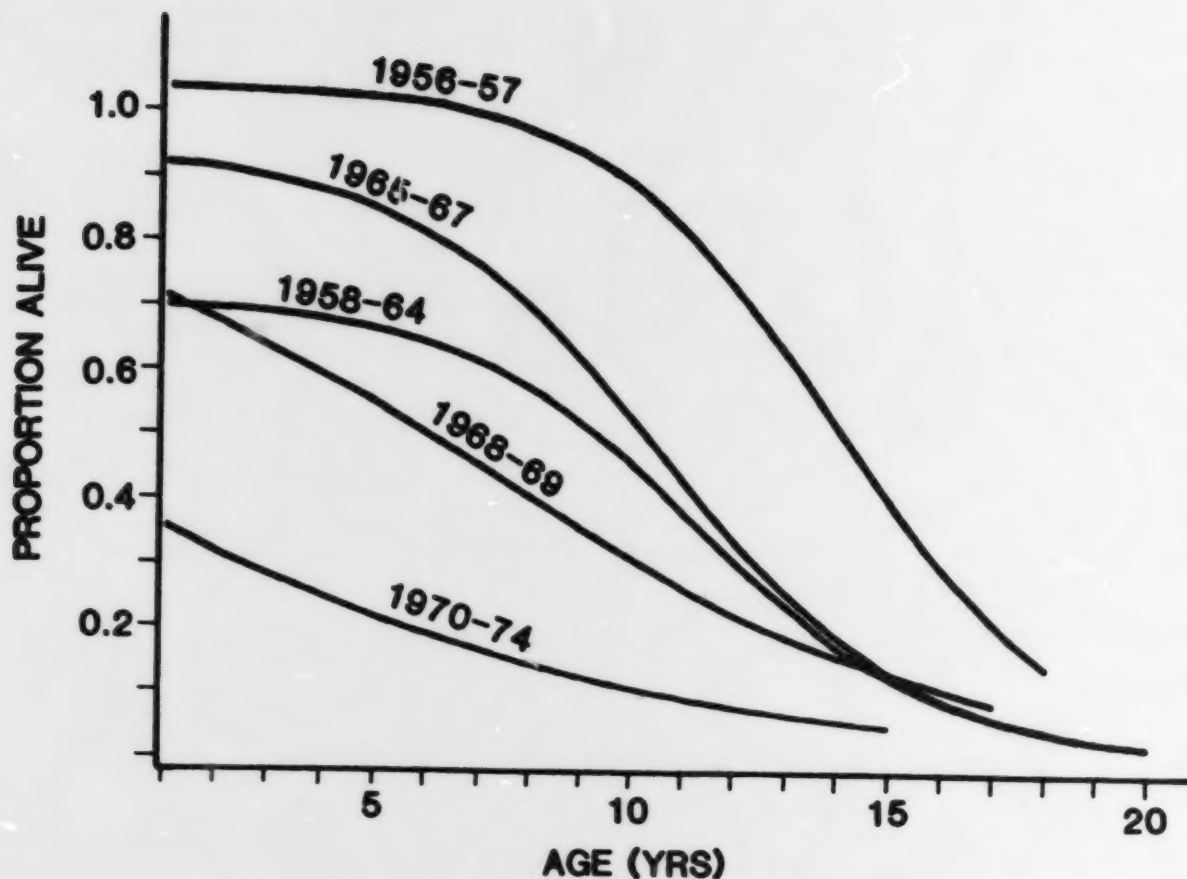


Figure 2. Survival curves for cohorts of Isle Royale moose. Moose born before 1958 showed high survival throughout life. After 1969, survival was consistently low. Other cohorts were intermediate in adult or juvenile survivorship.

Table 1. Results from SURVIVE of simulating a 5 year study of collared caribou with true mortality rates of 90% in one area and 80% in another.

- a. Sample size of 20 caribou in each area.
- b. Sample size of 50 caribou in each area.
- c. Sample size of 100 caribou in each area.

Likelihood Ratio Test Results

		<0.01	<0.05	<0.10	<0.50	<1.00
GENERAL	VS. CONSTRAIN	23	45	59	85	100

```
- INPUT --- proc stop /* 20 CARIBOU IN 2 AREAS */;
```

		<0.01	<0.05	<0.10	<0.50	<1.00
GENERAL	VS. CONSTRAIN	56	76	87	99	100

```
- INPUT --- proc stop /* 50 CARIBOU IN 2 AREAS */;
```

		<0.01	<0.05	<0.10	<0.50	<1.00
GENERAL	VS. CONSTRAIN	88	96	100	100	100

```
- INPUT --- proc stop /* 100 CARIBOU IN 2 AREAS */ ;
```

test between the importance of various factors using SAS. This technique shows great promise to integrate data from many studies into a single design. The current collaring effort is encouraging but insufficient time has elapsed for very many of the animals to die. Tests of the results that I have received to date are generally insignificant. I will continue to add data over the next few years as they become available and inform the attendants of my findings.

Conclusion

There are a range of techniques available to determine mortality rates of radio collared animals and the antecedent risk factors that can address almost any experimental design. Determination of mortality rates should become a standard product of any collaring effort, particularly because of the relevance of mortality to other studies and to general understanding of management needs. The integration of mortality estimates from telemetry with hunter returns and accessory age-structure information will provide the opportunity for accurate estimation of mortality rates of caribou in the very near future.

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4.5 CARIBOU IN BRITISH COLUMBIA: MANAGEMENT NEEDS FOR THE FUTURE

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Introduction

Looking to the future is part of being human. While that may be a fact, it doesn't provide much comfort to anyone trying to make projections into the future. All our thoughts are based on knowledge, and those related to describing a future condition or to planning future activities so as to reach a desired future state, are particularly demanding. Our success at projecting is built on being well informed of facts up to the present including the relative accuracy of those facts and the interrelationships and probabilities for success of various actions towards meeting our objectives.

It was with some trepidation then that I undertook to consider caribou management needs for the future in British Columbia. I was concerned because I'm not fully up on the rather extensive literature on caribou and my work provides me with only a generalized view of ongoing work on Caribou in the Province. To bring myself up to a reasonable knowledge level I have relied on my review of selected literature, related particularly to caribou in British Columbia, and the comments offered by persons attending this meeting.

My approach is to identify general management needs obviated by stated goal, objectives and policies and to compare them with current knowledge reported in the literature and at this meeting. I also look briefly at what is known about demand and use and supply and status of Caribou to see what management may be needed to meet the goal and objectives. I then project or speculate for purposes of discussion what I see as needs for management in the future.

Objectives

To clearly understand future management needs for caribou we must know the objectives to be met, the limits set as a matter of policy and the technical information and activities needed to meet objectives. From that we see our purpose, what we know and can do now, and what we may need to do in the future to meet the objectives. The management objectives for caribou are described in the "Preliminary caribou Management Plan for British Columbia" (British Columbia Ministry of Environment, 1979), hereinafter called the caribou plan.

Objectives:

1. Increase the caribou population to at least 20,000 animals distributed on traditional ranges.
2. Provide an opportunity for people to view caribou in their natural habitat.
3. Provide 20,000 hunter days of recreation and an annual sustained hunter kill of about 1,000 animals.

Those objectives may well be subject to change but for the present they represent the only statements by the managing agency providing a province wide perspective for caribou management.

Firstly, it is clear from information given in the caribou plan that to achieve population objectives attempts may have to be made to increase caribou numbers and to maintain them on traditional ranges. The needed change in the provincial population or its distribution is not clear given the objective of 20,000 animals is in the upper end of the estimated population range given in the caribou plan. The amount of effort required to meet the population objectives depends largely on what we know about the distribution and abundance of caribou. More recent surveys have confirmed minimum caribou estimates are higher than stated in the plan (Macgregor pers. comm.). Secondly, the achievement of objectives for viewing and hunting use depends on a knowledge of the amount and distribution of public demand. The information available or needed to address those management needs is dealt with in later sections.

The objectives for the management of caribou are qualified by the wildlife goal statement and policy. The goal of the wildlife programme is as follows:

The Goal (1985)

"To maintain the diversity and self sustaining ability of species representatives of the major biophysical zones of the province, and to ensure that, within the constraints of land capability and biological limits of each species, wildlife is available in sufficient abundance to meet the aesthetic, cultural, recreational, ecological and economic needs of society."

Among other things, the goal sets out the framework for assuring no species of wildlife is allowed to become extinct, removed from a major area of the province or too low in numbers to satisfy public demand for use. I will show later

more specifically how those conditions relate to future caribou management needs. In general, however, we must establish within which biophysical zones caribou must be maintained, what constitutes a self sustaining population, and the supply of caribou needed to satisfy public use if we are to meet the basic intent of the goal.

Policies:

In recognition of the traditional human harvest of caribou, their apparent vulnerability to harvest and to habitat alteration and their variable recruitment rates, a number of policies have been set out. The policies enunciated in the caribou plan confirm that caribou will be managed;

- as an integral part of wild ecosystems,
- as a game animal with harvests generally not more than 6% of fall populations
- on an area or herd basis and
- so that some herds will be closed to hunting and managed primarily for observation.

For the Wildlife Manager this means that he must know several key things including where caribou occur, what constitutes a population or herd, the numbers in each herd, the human harvest taken from the herd to within a few percentage points and the short and longterm effects of other factors which limit the numbers, growth and use potential of caribou. These information needs in combination with those obviated by the goal statement and the objectives for caribou management, set out the framework for describing management needs for the future. I next turn to considering which of those information needs, or others related to them, are satisfied by existing knowledge and management activities and which require future management or research emphasis. In this exercise I do not presume to duplicate the many intense hours of work carried out by others. Instead I will highlight major items of concern and offer some thought on the priority for such items on a provincial basis.

Demand and use

Caribou in British Columbia and elsewhere have been in demand for use by man since recorded time (1979, Kelsall 1968). In British Columbia today the demand is primarily oriented to observation or study and hunting for trophy, food or both (Reid 1985, Reid, et al. 1985). Caribou are not legally available for use for sustenance purposes. However, illegal use of the resource for this purpose is apparent (Bergerud 1978, 1979). In the seven years from 1978 to 1984

an average of 1,335 resident and 486 non-resident hunters have bought licenses to hunt caribou in B.C. and harvested an average of 143 and 187 animals each year respectively. For the eight years from 1970 to 1978, 3,765 residents and 1,279 non-residents bought licenses to hunt caribou and harvested an average of 731 and 552 animals each year respectively. The main reason for the sharp decline in harvest and demand (licenses sold) was probably related to the greatly reduced hunting opportunities resulting from regulation changes (maps 1 and 2). That action was a direct result of recommendations of Bergerud (1978) who reported low recruitment, probably due to predation, and excessive human harvest, which had probably decreased estimated caribou populations from a high of 24,000 in 1970 to 10,500 by 1978.

Two 1981 public surveys showed the gross economic value to British Columbia attributed to caribou hunting was \$1.1 million (\$0.2 million net) for residents and nearly \$0.8 million (\$0.5 million net) for non-residents (Reid 1985). These same surveys showed that caribou hunters represented less than 1% of all B.C. hunters and caribou were the eighth most preferred species sought out of 13 choices by resident hunters and the fourth most preferred species sought by resident caribou hunters. Resident caribou hunters spent significantly more per day than all other resident hunters. Fifty-four percent of the resident hunters who hunted caribou in 1981 planned to hunt the following year and 51% were satisfied with their hunt in 1981. Seventy one percent of the non-resident caribou hunters were satisfied with their hunt in 1981. Based on the survey results, hunters were more likely to hunt caribou as a combined hunt species rather than as the sole purpose of their hunt compared to other resident hunters. This may account for their relatively low preference ranking of the species. Non-resident caribou hunters were more likely to hunt caribou as the primary species of interest.

A 1983 survey to determine the non-hunting interests in wildlife of voting age (adult) B.C. residents did not yield information specific to caribou, however, preliminary results did show that of the 1.5 million adults in B.C. 111,000 people made special trips or outings to enjoy Mountain sheep, Mountain goats and caribou. Results indicate that the degree of involvement with large mammals varied with the region of residence and the relative abundance of the wildlife species (Reid et al. 1985). Eighty-nine percent of the respondents to that survey felt the quality of their experiences were average or better and 75% felt the Wildlife Branch was doing an average or better job of providing opportunities for non-hunting. Seventy five percent of the adult population (ie. 1.1 million people) were involved in some wildlife use (direct, indirect or around cottage or home) and they spent an estimated \$490.6 million in 1983. They also indicated

their total consumer surplus value was \$200 million. Of particular interest was an indicated willingness to pay an additional \$106 million to preserve the present abundance and variety of Wildlife. That same interest in maintaining wildlife variety was apparent from the public comment on the proposed wildlife Management Plan for British Columbia (1979), the results of which were summarized in a separate report (1980).

The results of the hunter surveys cited above confirm a continuing interest in the traditional hunting use of caribou. This is so even though hunting opportunities have diminished in recent years as illustrated by comparing caribou hunting seasons between 1959 and 1972 with those between 1978 and 1985 (Maps 1 and 2). The survey to determine non-hunting use of wildlife (Reid et al. 1985) did not assess specific interests in caribou but it did indicate considerable support for the maintenance of wildlife species and their current abundance. The Surveys of hunters and non-hunters (Reid 1985, Reid 1985) did not indicate a demand for more caribou but clearly hunters have demonstrated a higher demand for caribou in the past when hunting opportunities were more widespread and less restrictive. Indeed, the relatively low level of satisfaction with the hunting experience in 1981 indicated by caribou hunters compared to other hunters may relate to poor hunting opportunities. It seems reasonable to assume demand would increase again with increased opportunity and that this would likely be so for resident and non-resident hunting and non-hunting uses. The survey information generally supports the wildlife goal and caribou objectives which relate to the maintenance of species diversity, population numbers, use levels and opportunities. I have not found more specific information on future demand on an individual population or herd basis, nor did I find information on the value of individual species in each management region for non-hunting uses. That information is needed if all objectives are to be met.

Supply and Status

Knowing where animals are, their numbers and status is vital to achieving almost any management strategy. Yet, the distribution and abundance of caribou in British Columbia are poorly known (Bergerud 1978, Stevenson and Hatler 1985). Information provided in the Caribou Plan (1979) indicated an estimated provincial population of 10,500 animals with estimated limits from over 9,000 to under 20,000 animals. The minimum population is now believed to be 12,000 (Macgregor pers. comm.) but there is no way of knowing if the change is real since not all areas occupied by caribou have been surveyed recently and probably not adequately to measure

a change (Stevenson and Hatler 1985). Approximately 90% of the provincial caribou population occurs in the northern two-thirds of the province (ie. Skeena, Omineca and Peace Management regions). While a generalized map of small scale has been used to depict the distribution and relative abundance of caribou in the caribou plan, little is really known about the actual size, status and range of individual populations and the methods for determining those facts are poorly developed (Stevenson and Hatler 1985). Bergerud (1978) described individual herds and recommended their use for management but he too identified a considerable absence of good census information and uncertainty about the range and interchange of animal groups.

It is apparent from the work of Bergerud (1978), Wildlife Branch staff (1979) and others (Freddy and Erickson 1975, Jerry 1983, Stevenson and Hatler 1985) that individual populations of caribou are very poorly known. Yet that information is vital to achieving the stated wildlife goal and caribou objectives and policies.

It is also vital we learn about the relative impact of natural and human caused mortality. We are only now just starting to learn about some aspects of how wolf-caused mortality influences calf recruitment and the status of populations, and how natural mortality and human harvest interact (Bunnell et al. 1975). The amount of illegal harvest or accidental kill is unknown.

How can we safely set the harvest limit for a population without a knowledge of mortality? Bergerud (1978) in particular emphasized the need for managers to quantify the relative impacts of predation and human harvest. He pointed out that people must decide whether they want huntable caribou populations or undisturbed predator-prey systems and that, if they wanted the former, wildlife managers would have to be allowed to manage wolves and other predators. Dr. Bergerud also pointed out that the most important management tool is a measure of annual recruitment and that it, in combination with the population size, allows the manager to set harvest quotas. Dr. Bergerud underscored the difficulty in getting good recruitment information particularly inventorying for long (17 month) and short (10 month) yearlings. He emphasized the need for recruitment and population information very pointedly when he said . . . "If a herd can neither be counted nor recruitment measured it cannot be managed and thus it should not be hunted" (Bergerud, 1978). He stressed that managers should close hunting until recruitment is known.

Do we know the limits of a self sustaining population, its size and habitat needs? This is clearly a key consideration for some of the smaller groups of animals, particularly in the south (Stevenson and Hatler 1985). It is a prime concern to plan for the management of our southernmost herd of caribou in the Selkirk Mountains (Jerry 1983). Presently we don't have much more than a theoretical perception of what should be a minimum population. Under the cooperative management plan for the Selkirk Caribou a minimum population which is "genetically effective" is set at 50 animals (Jerry 1983). The projected population under the plan at which recovery will be considered achieved is 100 animals, with at least one other population nearby to assure interbreeding.

Given the state of our knowledge about caribou numbers and distribution it is not surprising that little more than generalized statements can be made about the habitat needs of almost all caribou in the province. Some recent efforts to radio mark individual animals in some populations is helping to turn this around, but, it is frustrating for wildlife managers and other resource managers they work with, given that decisions on land and resource use must be based on such limited knowledge. This is particularly highlighted in the recent work of Stevenson and Hatler (1985) where they review the status of woodland caribou in southern and central B.C. with an emphasis on relationships with forest management practices. That work and the work of Bergerud (1978) and Freddy and Erickson (1975) point out the need to know more about the short and long term effects of man-caused habitat changes such as logging, roads and fire (use or control) and the influence these changes have on food, cover, predation, movement and human use. There's a need to know which biophysical zones are important to caribou so that that cardinal point in the Wildlife Goal statement can be addressed. If we don't know the range and habitat use of caribou we cannot say which biophysical zones they occupy or what degree of animal interchange there may be between areas.

On that point I find myself at odds with recommendations of Stevenson and Hatler (1985) who suggest we should identify caribou in the areas of Tweedsmuir Park, Prince George east and Wells Gray Park as high priority provincially for management and research, while having other areas with caribou regarded as medium priority and managed in a regional framework. I did not find there was enough information available on which to make such decisions although I support the analytical approach used by Stevenson and Hatler in coming to their conclusions. I believe instead that we must continue to work to keep as many of our study and management options open as possible for preserving the distribution of caribou in the province, while we collect the

necessary information to more clearly identify priority areas. Recognizing the resources aren't available to study all caribou in all areas, those efforts will have to be focused on key study areas. I feel it is prudent to emphasize key areas now receiving special attention and to add other key areas needed to adequately "sample" the range of caribou in the province. As knowledge grows from studies in those areas management efforts can be modified in other areas. The following areas have recently received some level of study (primary investigators indicated in brackets), many including radio collared animals. They should be considered as candidate key study areas for the management-research programme.

- Selkirk Mts. (Cooperative management plan)
- Revelstoke (Revelstoke dam impact study)
- Wells Gray (Wildlife Program Studies)
- Caribou highlands (Wildlife programme studies)
- Tweedsmuir Park (Wildlife programme studies)
- Spatsizi Park (Spatsizi Association for Biological Research cooperative studies)
- Horseranch (Wildlife programme studies)
- Muskwa (Wildlife programme studies)

Future Needs

A number of management and research needs have been identified by Freddy and Erickson (1975), Bergerud (1978), Jerry (1983) and Stevenson and Hatler (1985). I have listed the major needs below and assigned a tentative high or medium priority to them from a management perspective, based on my brief review of the recommendations of those authors and a review of the Wildlife Goal and Caribou Management Objectives and policies of the B.C. Wildlife Branch. I have not made an effort to distinguish whether a particular need requires a management or a research input or both. I will leave that to the technical experts to decide.

Priority

- | | |
|------------------|--|
| High - Inventory | <ul style="list-style-type: none">- establish consistent, suitable methods to record animal numbers and population compositions- determine populations (herds), population dynamics, distribution, and the numbers and composition of populations, and the degree of interchange between populations.- determine the natality of populations, determine the cover needs of populations (ie. Thermal, hiding and insect cover). |
|------------------|--|

- Determine the selectiveness of caribou for various habitat components.
- Determine public demand for the use of each population and set out possible objectives for the management of each population.
- Determine which populations of caribou are required to maintain a self-sustaining population in each biophysical zone.
- Determine the minimum size of a self-sustaining population.
- Determine seasonal energy needs of caribou and the areas they require.
- Assess the impact of predation in controlling caribou populations.
- Understand the short and long term effects of various logging practices on lichen growth and abundance (Mt. Caribou ecotype), other aspects of caribou habitat, caribou populations and man's use of caribou (i.e. access).

Medium - determine populations which are priority areas for the management of caribou to meet the Wildlife Goal, provincial objectives and management policies and facilitate the research needed for improving management in the future.

- determine age of first breeding
- Assess impact of proximate mortality, poaching, traffic accidents, etc. and relationships to man-caused habitat changes.
- Understand the role of fire in caribou forest types and the short and long term effects on caribou populations.

It takes time for new knowledge to accumulate and for its application in resolving management concerns, but managers must continue to manage none-the-less. To ensure caribou are managed within reasonable limits to meet provisions of the Wildlife Goal, caribou objectives and policies I believe a conservative management strategy has to continue to be employed. The information referred to earlier in this paper and gleaned from this workshop supports the stock and habitat management strategies listed below. I present them for discussion and debate not as a set of recommendations.

Stock Management Strategies

1. Allow a conservative male only hunter harvest where October surveys conducted within the previous three years provide information to confirm;
 - a population greater than 100,
 - a calf component greater than 15% of the total population and
 - a male to female ratio no greater than 1:4 for the population.
2. Close all populations to hunting not within the limits described in item 1. above.
3. Continue to manage caribou on a herd basis using up to date survey information and adjust herd descriptions as new information allows.
4. Make estimates of illegal kill and accidental human kill using all available information from enforcement staff and the public and deduct it from the annual estimate of allowable harvest for each herd.
5. Emphasize hunting use on herds which can be safely harvested and non-hunting use on herds with suitable access and numbers until surveys can be conducted to verify a different public demand on a herd or local area basis.
6. Undertake restocking/transplants where feasible with marked animals, to maintain or recover caribou distribution and to test habitat suitability in understocked or vacant areas.
7. Continue to reduce predators (other than grizzly bear) where necessary to meet demand and predation is shown to be the key limiting factor and to yield a positive cost benefit within a ten to twenty year timeframe (with their low reproductive rate and high value grizzly bear should take precedence over caribou).
8. Complete and update periodically, regional and provincial wildlife plans to reflect new knowledge about public demand and the status of populations/herds.

Habitat Management Strategies

1. Continue to press for optimum forest management practices and other land uses to benefit caribou and maximum fire protection in sub-alpine forests within the historic range of the "Mountain Caribou ecotype" to ensure;
 - maintenance of arboreal lichen bearing trees, and
 - the development of minimum road access or the retirement of roads wherever feasible.
2. Minimize constraints on forest management practices and other land uses within the historic range of the terrestrial lichen caribou ecotype except those related to road access as described under 1 above.

In general the strategies described reflect my belief that the limiting effects of harvest and habitat loss are not known beyond the level of general principles and that the impacts of harvest can be reversed within a twenty-five year timeframe while those of habitat loss cannot be reversed within less than a 100-250 year timeframe. I therefore believe we must be more conservative in dealing with habitat impacts.

Recommendations:

I believe this workshop has been successful at bringing together caribou research and management experts and at providing them with an opportunity for an exchange of information on the "state of the art" in caribou management particularly as related to ongoing efforts in British Columbia. However, more emphasis on the application of the up to date information in day to day caribou management is needed and this was only touched on at the workshop. I recommend the Wildlife Branch carefully review the information available through this workshop and set out a set of strategies for management and research of caribou over the next five (5) years. This task should be undertaken by a group of wildlife programme staff and it should be actioned in the near future. The task groups' recommendations should be approved by the Wildlife Programme Director to assure the necessary commitment to their implementation.

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APPENDICES

APPENDIX 1. Open letter from Terje Vold

RE: Caribou Workshop

I wish to express my appreciation for a very rewarding, stimulating, and well organized workshop on caribou that you arranged last November in Kamloops.

You thoughtfully asked participants for their ideas on the future direction of caribou research. I have some comments for your consideration:

1. It didn't appear to me as if any caribou research projects really addressed the issue of effects of logging and related activities (e.g. access roads) on caribou. Even the "Quesnel Highlands" may not be relevant (at least at present) because most of the logging activity in the "logged" area is at lower elevations below which caribou normally use.

The already sensitive issue of forest harvesting impacts on caribou will likely increase in concern; thus, I feel the highest priority research effort needs to be centred around this issue. The possible ways logging may affect caribou, outlined by Rick Page at the workshop, appears to be an excellent way to structure future research.

2. The approach taken by you in the Kimsquit to study the effects of logging-related activity on grizzlies appears to be equally valid for caribou. It is essential that some kind of pre-logging assessment of caribou populations, behaviour and habitat use be determined first, then a study of how they respond to forest harvesting activity, and, finally, periodic follow-up studies after logging is completed.
3. Since caribou behaviour seems variable in different parts of the province, depending in part on the effects of predation and habitat use, I would suggest 3 or 4 areas of study as opposed to putting all efforts in one area. Suggested areas of study are:
 - i) Revelstoke. Use Keith Simpson's baseline research, and have it continued now that logging is becoming more extensive in this area. This study would represent arboreal lichen feeders where predation appears not to be as great a factor as believed in other areas.
 - ii) Quesnel Highlands. Should logging continue in the "logged" area to higher elevations that caribou use, then this area in combination with the "control" area is obviously a study worth continuing. We need to know which commercial forest stands, if any, need to be reserved from logging for caribou. This study represents arboreal lichen feeders where predation appears to be a major factor controlling populations.

- iii) Tweedsmuir. Logging in caribou winter range (the Laidman Lake area) is beginning and is likely to be a major issue of concern as it progresses. Research could take advantage of this and Rick Marshall's radio-collar tracking effort to help in assessing logging impacts.
 - iv) Itcha/Ilgachuz. This major herd will be surrounded by forest access development (thanks in part to the mountain pine beetle), thus access impacts (direct and indirect) need to be carefully monitored/studied. Winter ranges could be affected by logging and logging effects need to be examined.
4. In summary, it seems to me research efforts already begun in these areas need to be coordinated and augmented with your help and support in such a fashion as to allow direct study of logging impacts on caribou. This will mean adding an extra dimension to these studies to ensure that findings are both sound and comparable to each other. Rather than finding a "new" area, it seems building on these existing efforts in obvious areas of concern would be best.

Again, I appreciate very much attending the excellent workshop you organized and look forward to the proceedings.

Kind regards,

Terje Vold, R.P.F.
Forestry Specialist, Habitat Section
Wildlife Branch, Ministry of Environment
Victoria.

APPENDIX 2. List of Registrants

Name	Affiliation
Ray Addison	MOF
Ted Antifeau	UBC
Namik Arkun	MOF
Harold Armleder	MOF
Ted Baker	MOF
Norm Baricello	Yukon Dept. Wildlife
Tom Bergerud	U Victoria
Heather Butler	U Calgary
Mike Carlson	MOF
Bob Cavill	Interior Lumber Manuf.
Ken Child	MOE
Jerry Childs	Gulf Canada
Debbie Cichowski	UBC
Tim Cowley	Okanagan College
Rick Dawson	MOF
Monty Downs	MOLPH
Don Eastman	MOE
Al Edie	MOE
John Elliott	MOE
Rick Ellis	MOF
Rick Farnell	Yukon Fish and Wildlife
Mike Fenger	MOE
Dene Ferguson	MOF
Bristol Foster	Private
Gerry Fox	MOE
Hal Giles	MOF
Ray Halladay	MOE
Alton Harestad	SFU
Fred Harper	MOE
Paul Harrington	US Forest Service
Connie Harris	Private
Dave Hatler	Private
Ian Hatter	MOE
Darryl Hebert	MOE
Jerry Hickman	Washington Dept. Game
Greg Jadrzyk	Council of Forest Ind.
Ron Jakimchuk	Renewable Resources
Greg Jones	MOLPH
Tom Juelson	Washington Dept. Game
Dave King	MOE
Jerry Korol	UBC
Ted Lea	MOE
Bob Lincoln	MOE
Dave Low	MOE
Wally Macgregor	MOE
Gordon Mackinnon	MOE

Rick Marshall	MOE
Grant Mc Hutchon	SFU
Bob Mc Fetrige	Alberta Ener. Natur. Res.
Dave Melenka	Crestbrook Ind.
Dave Meehan	Weyerhaeuser
Leverne Merkel	MOF
Mel Monteith	MOF
Brian Nyberg	MOF
Yukio Ozawa	MOF
Rick Page	MOF
Kat Palmer	Private
Bruce Pendergast	MOE
Jim Pojar	MOF
Ralph Ritcey	MOE
Chris Ritchie	SFU
Fraser Russell	MOF
Bob Scheer	MOLPH
Mike Scott	Idaho Dept. Game and Fish
Dale Seip	UBC
Gregg Servheen	Idaho Dept. Game and Fish
Keith Simpson	Private
Kirby Smith	Alberta Ener. Natur. Res.
Tom Smith	MOE
Jim Smith	MOF
Al Sobotin	MOE
Gerry Stenberg	MOF
Susan Stevenson	Private
Doug Steventon	MOE
Ken Sumanik	Private
John Szauer	MOF
Max Tanner	MOF
Dave Vales	UBC
Ben Van Drimmelen	MOE
Phil Van Mol	MOF
Terje Vold	MOE
Glen Watts	MOE
H. Willis	MOF
Guy Woods	MOE
Jim Young	MOE

Abbreviations

MOE	Ministry of Environment
MOF	Ministry of Forests
MOLPH	Ministry of Lands, Parks and Housing
SFU	Simon Fraser University
UBC	University of British Columbia